United States Military Academy
West Point, New York 10996

RESEARCH PLAN

OF THE

OPERATIONS RESEARCH CENTER AND DEPARTMENT OF SYSTEMS ENGINEERING

FOR THE

ACADEMIC YEAR 2003

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INTRODUCTION

The purpose of this document is to formalize the research and problem-solving activities of the *U.S. Military Academy Operations Research Center for Excellence* (ORCEN) for the upcoming academic year. The research plan includes a statement of purpose for the ORCEN, a description of its organization, a list of the key personnel responsible for executing the plan, and an overview of the annual research cycle. These are followed by a concise summary of each applied research or problem-solving project. The summary includes a problem statement, a proposed methodology for project execution, project requirements and deliverables, estimates of milestones, and the number of man-years required to complete the work. Additional information is provided on the senior investigator, principal analyst, the client organization, and points of contact.

The ORCEN serves as the coordinating body for all research undertaken within the Department of Systems Engineering. As such, this plan encompasses a range of projects and work performed by ORCEN Analysts, Senior and other Faculty members and Cadets alike. These research activities are opportunities to develop research and problem-solving skills while working on problems that are of importance to today's Army.

PART I – THE OPERATIONS RESEARCH CENTER OF EXCELLENCE (ORCEN)

Purpose of the Operations Research Center

The purpose of the Operations Research Center is to provide a small, full-time analytical capability to both the Academy and the United States Army. The Operations Research Center helps to fill several Academy needs: (1) enriched education for cadets; (2) enhanced professional development opportunities for Army faculty; (3) maintenance of strong ties between the Academy and Army agencies; and (4) the integration of new technologies into the academic program.

By being fully engaged in current Army issues, the Operations Research Center assures that systems engineering education at West Point remains current and relevant. The one-year experience tour with the ORCEN offers officers assigned to the Academy, as faculty, the opportunity to engage in meaningful applied research and problem solving activities that both enhances their professional development as Army officers and keeps them current in their disciplines. The Army's return on its investment, depicted in Figure 1, is meaningful career development experiences for officers, especially those in Functional Areas 49/51/53, an enhanced education program for the West Point cadets, and important investigation of vital Army problems at far less cost than would be required through civilian contracts.

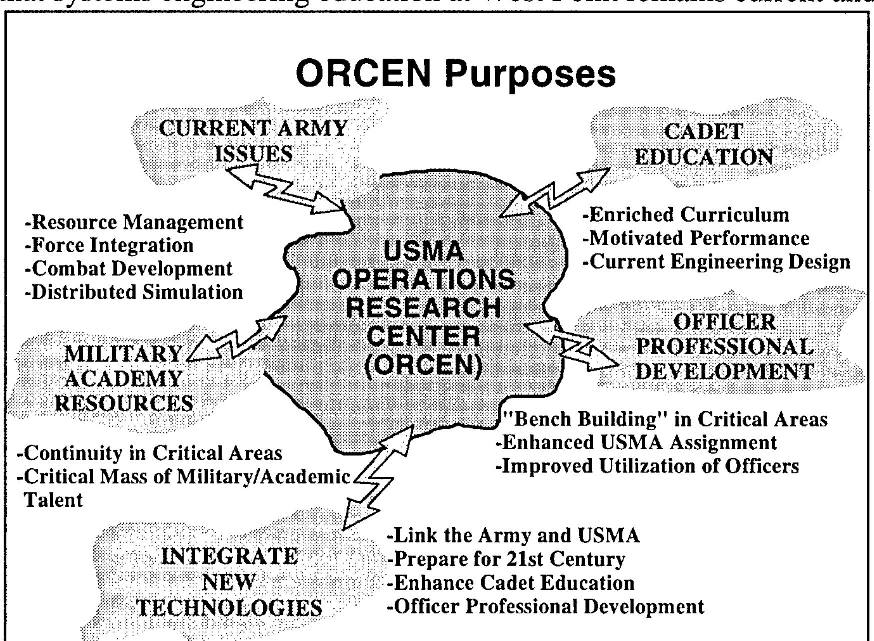


Figure 1: Purposes

Operations Research Center projects provide the faculty and cadets with the opportunity to investigate a wide spectrum of interdisciplinary, systemic issues and to apply many of the systems engineering, engineering management, and operations research concepts studied in the classroom to real-world problems of interest to the Army. These projects demonstrate for both cadets and faculty the relevance and importance of systems engineering in today's high-technology Army.

Organization of the Operations Research Center

Personnel authorizations in the ORCEN are established by a Table of Distribution and Allowances (TDA). Funding support for the Operations Research Center is established by a Memorandum of Agreement with the Office of the Assistant Secretary of the Army (Financial Management). The Operations Research Center is organized under the Office of the Dean as an Academy Center of Excellence. A permanent USMA Academy Professor provides oversight and supervision to the Center. In addition, the TDA authorizes one analyst, O5; three analysts, O4 and a secretary GS5. By agreement between the Department of Systems Engineering (D/SE) and the Department of Mathematical Sciences (D/MATH SCI), three analysts are assigned to the ORCEN by D/SE, and one analyst from D/MATH SCI. The Department of Systems Engineering also provides the permanent faculty member to serve as the Director and one permanent staff member to serve as Executive Administrator and assistant to the Director.

The Operations Research Center welcomes the opportunity to collaborate on Army-related projects with USMA teaching faculty from the Departments of Systems Engineering, Mathematical Sciences, and others. In addition, the ORCEN is able to provide Army officers attending graduate school and cadets enrolled in advanced individual study courses with real-world projects that are well suited for either thesis work or course projects. This in turn provides Army agencies with a greater range of expertise to address a wide spectrum of projects.

The Operations Research Center occupies office and laboratory space in the Department of Systems Engineering on the third floor of Mahan Hall. The Center includes offices for the director and analysts, and a briefing area. The Department of Systems Engineering laboratories -- Combat Simulation, Systems Management and Design, and Computer Aided Design -- are located within easy access to the Operations Research Center.

The Operations Research Center is sponsored by the Assistant Secretary of the Army (Financial Management & Comptroller). Fully staffed and funded since Academic Year 1990-1991, the Operations Research Center has made significant contributions to cadet education, faculty development, and the Army at large (see Figure 2 below for example flow of projects).

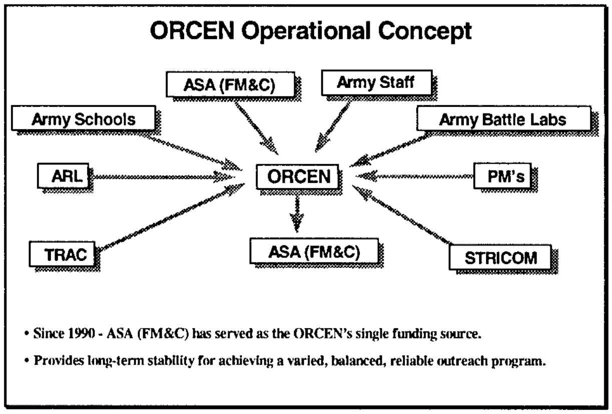


Figure 2: Operational Concept

Personnel Involved in ORCEN Research

The following is a list of key personnel from the Operations Research Center responsible for executing the Research Plan for the Academic Year 2003. A detailed description of each research project is given in Part III - PRINCIPAL RESEARCH ACTIVITIES FOR AY03.

TITLE & ORGANIZATION	NAME	PHONE (DSN)	EMAIL
Professor and Head, Department of Systems Engineering	COL Michael L. McGinnis, Ph.D.	688-2701	fm0768@usma.edu
Associate Professor & Director, ORCEN	COL William K. Klimack, Ph.D.	688-5529	fb5901@usma.edu
D/SE Analyst & Assistant Prof essor	LTC Timothy Trainor, Ph.D.	688-3688	ft5890@usma.edu
D/SE Analyst & Assistant Professor	MAJ David M. Sanders, M.S.	688-5539	fd9356@usma.edu
D/SE Analyst & Assistant Professor	MAJ Patrick Magras, M.S.	688-5114	fp5433@usma.edu
D/MS Analyst & Instructor	MAJ Christopher M. Farrell, B.S.	688-5661	ac9703@usma.edu

These full-time analysts are augmented by permanent faculty who serve as senior investigators for each project, as well as by instructors from the Department of Systems Engineering, the Department of Mathematical Sciences, and other departments who work as primary analysts or co-analysts on ORCEN projects. The primary faculty members who will be involved in ORCEN related research this year are:

ACADEMIC RANK	NAME	PHONE (DSN)	EMAIL
Professor	Patrick J. Driscoll, Ph.D.	688-2700	fp5543@iusma.edu
Professor	Bobbie Foote, Ph.D.	688-4893	fb9690@usma.edu
Associate Professor	COL William B. Carlton, P.E., Ph.D.	688-4698	fw5058@usma.edu
Associate Professor	Gregory Parnell, Ph.D.	688-4374	fg7526@usma.edu
Associate Professor	LTC Willie McFadden, Ph.D.	688-5534	fw1793@usma.edu
Associate Professor	LTC Margaret Belknap, Ph.D.	688-4625	fm0673@usma.edu
Assistant Professor	LTC James Buckingham, P.E., Ph.D.	688-5181	fj0430@usma.edu
Assistant Professor	Roger C. Burk, Ph.D.	688-4754	fr6961@usma.edu
Assistant Professor	LTC Michael J. Kwinn, Jr., Ph.D.	688-5941	fm9536@usma.edu
Assistant Professor	Lt. Col. Edward Pohl, Ph.D.	688-5206	fe6428@usma.edu
Instructor	Paul West, M.B.A.	688-5871	fp8049@usma.edu

PART II – RESEARCH PROGRAM OF THE ORCEN

Purpose of the Research Plan

As the US Military Academy develops the leaders of tomorrow, it is important that it maintains ties to the Army of today. This document helps to highlight for Army leaders, external agencies, and visitors the important links between the Academy and the Army that are strengthened through research activities conducted by the ORCEN. The Center provides a limited number of Army agencies with dedicated, long-term, applied research and problem solving capability specializing in the application of both operations research and systems analysis (ORSA) and the systems engineering design process (SEDP). A partial listing of past clients includes the following:

Assistant Secretary of the Army for Financial Management & Comptroller (ASA-FM&C)
Office of the Deputy Chief of Staff for Operations (ODCSOPS)
Office of the Deputy Chief of Staff for Personnel (ODCSPER)
Office of the Deputy Chief of Staff for Logistics (ODCSLOG)
Training and Doctrine Command (TRADOC)
TRADOC Research and Analysis Center (TRAC)
Army Personnel Command (PERSCOM)
Various Army schools and other agencies.

The academic term research plan serves as an important planning and execution document in the development of the Operations Research Center of Excellence extended research plan.

How to Initiate a Project with the ORCEN

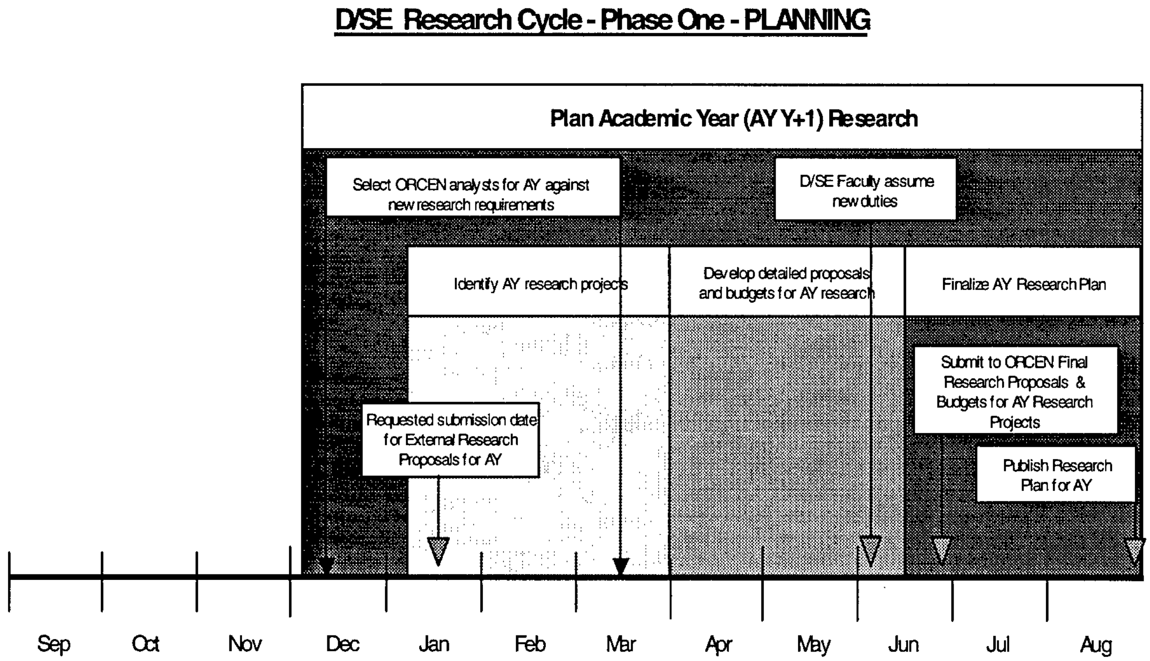
The Research Cycle for any given Academic Year for the Operations Research Center (ORCEN) is illustrated in Figure 3 on the following page. This is a depiction of the objective annual research cycle, which involves several processes in executing the Research Plan. Among them is the identification and evaluation of projects, the formalization and finalization of the plan, and the execution of the plan. These stages may occur concomitantly.

Throughout the year, ORCEN analysts and permanent faculty members in the Department of Systems Engineering seek to identify potential project for the out-years. At the same time, potential analysts are identified who have the abilities and desire to support each of the projects. Then, the slate of potential projects is evaluated, and a final list of projects is developed. After the academic term ends in May, new analysts from the Systems Engineering and Math faculties assume their duties in the ORCEN in support of the planned research activities. These analysts conduct an in-depth Needs Analysis with the client organizations for each project, and then finalize the research plan. Research activities throughout the year are closely coordinated with the client organizations, and normally are completed by May or June of the following year.

This cycle is the best way to ensure that a full academic year (June through May) is available to execute the research plan. This helps insure adequate time is available for the primary analysts and senior investigators to complete their research projects during the course of the academic year.

The annual research cycle benefits both incoming analysts and the ORCEN. First, it gives potential analysts an opportunity to become familiar with possible areas of research, and allows them to make their own research interests known. Second, it facilitates balancing the analytical needs of the ORCEN with the analytical skills, capabilities, and interests of the incoming analysts.

A key advantage of having the research cycle tied to the academic year is that it becomes possible to identify potential independent senior-level study projects for the fall semester of the upcoming academic year, to link specific cadet capstone design projects to the ORCEN projects. Additionally, it facilitates the opportunities for cadets to spend time during the summer working directly with Army-related clients in Advanced Individual Academic Development courses (AIADs).



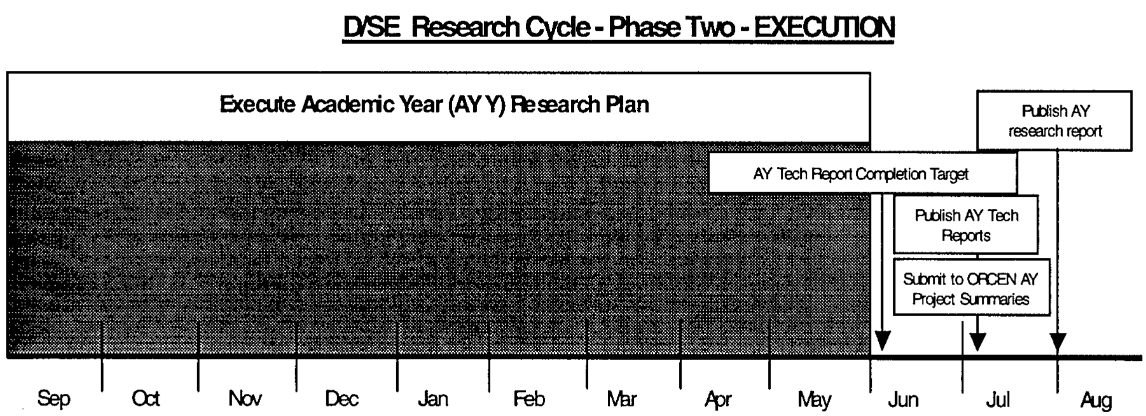


Figure 3: DSE/ORCEN Annual Research Cycle

PART III – PRINCIPAL RESEARCH ACTIVITIES FOR AY03

The following pages list each planned research project to be undertaken within the Department of Systems Engineering for Academic Year 2002-2003, otherwise referred to as AY03.

Evaluating the Effectiveness of Interactive Multimedia Instruction for Soldier Tactical Mission Systems (STMS)	PM-Soldier Systems	46
Global Combat Support System-Army Analytic Support	PM-Global Combat Service Support System-Army (GCSS-A)	49
Installation Vulnerability and Risk Assessment Tool	ASA(FM&C) & ACSIM	51
Methodology for the Management of Power for the STMS	TBD	53
Small Aircraft Transportation System (SATS): Airspace Infrastructure Modeling & Simulation	NASA/Langley Research Center	57
STMS Component Optimal Distribution	PEO-Soldier	60
Airport Security for the 21st Century	John Wayne Airport Commission	62
Analysis and Comparison of VoTech programs, current Military Occupational Specialties (MOS) and US Army Advanced Individual Training (AIT) requirements associated with these MOSs – Part 1.	USAREC	64
Objective Force Manning and Personnel Development	PM-Objective Force	67
Programmic Analysis of Recruiting Inputs	USAREC	69
Unit Manning Study	Army G-1	71
Logistics Decision Support System	TBD	74
Modeling of STMS Combat Effectiveness	PEO-Soldier	76
Quantifying Army Transformation	HQDA, DCSOPS (DAMO-ZR)	78
Security & Storage Design for STMS at Installation Level	PEO-Soldier	80
A Comparative Analysis of Methods for Assessing Cost & Schedule Risk for Major Defense Acquisition Programs	Office of the Secretary of Defense	82
Embedded Training Decisions Support	PM-Tank	85
Fleet Selective Maintenance and Aircraft Scheduling	The Logistics Institute (TLI)	87
Multi-Mission Selective Maintenance Decisions	TLI	91
Quantifying the Impacts of Aircraft Cannibalization	TLI	94
Deployment Scheduling Analysis Tool (DSAT)	Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)	97

Any questions regarding these problem statements should be directed to the D/SE Senior Investigator, the Principal Analyst, or the Client POC listed for the respective research project.

Imagery Collection as an Enhancement to the Disposable, Air-droppable, Meteorological Tower Array (DAMTA) for Intelligence Gathering on the Battlefield

Research Project No: DSE-R-0301

Client Organization: Army Research Labs, Battlefield Environment Division, Weather Exploitation Branch – White Sands Missile Range, New Mexico.

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
Dr. Doug Brown	US Army Research Laboratory ATTN: AMSRL-CI-EW (D.R. Brown) WSMR, NM 88002-5501	AV 258-1222/5/8 Comm. 505-678-1222	dbrown@arl.army.mil
Dr. Roger Smith	Geophysical Institute, University of Alaska Fairbanks, Fairbanks, AK 99775-7320	(907) 474-7416	roger.smith@gi.alaska.edu

Problem Description:

The Army Research Laboratory, Battlefield Environment Division, at White Sands Missile Range, New Mexico is currently involved in overseeing the development of a new battlefield intelligence gathering resource. The purpose of this effort is to provide the Army with a capability to gather meteorological data from battlefield areas that are data sparse. This data is required in order to enhance the accuracy of the Battlescale Forecast Model, as used in the Integrated Meteorological System (IMETS). The IMETS is the provider of meteorological information for the fielded Army.

This new resource, deemed DAMTA (Disposable, Air-dropable, Meteorological Tower Array) will consist of multiple individual meteorological towers which will be dispersed over selected battlefield locations by an airborne platform. The towers will be capable of self-erecting to the vertical after being dropped from a moving aircraft at no less than 2000 feet and at speeds up to 120 knots. They will collect and transmit data for up to 30 days.

These towers, once deployed, will communicate collected information to a central node (tower) which will in turn provide data to the IMETS and ultimately to the individual users. The towers will be of two varieties. Type I towers will have a fixed set of meteorological sensors and Type II towers will have the same sensors as well as the capability to add up to five additional ones. The Type I sensor set will measure wind speed and direction, temperature, humidity and barometric pressure. The Type II set may also include sensors for rain rate, precipitation amount, ground moisture, vertical wind and digital imagery. The DAMTA project encourages the use of off-the-shelf technology. Digital imagery in particular is the focus of this proposal as it provides valuable information not available through other sensors and yet highly desirable on the battlefield.

The basic DAMTA platforms will be prototyped within 24 months. The basic (Type I) weather sensor package has been used in many peacetime applications over the last two decades. The digital imagery enhancement is an innovative and important addition that will enhance the platform enabling it to provide intelligence beyond weather information.

The author and primary researcher for this project has conducted prior research into the technical feasibility, applicability and benefits of using remote sensing imagery. This study was accomplished as part of doctoral research to improve weather reporting at remote locations in Interior Alaska. These rural locations suffer from nonexistent, or unreliable and insufficient systems to collect information about weather conditions. For 15 months, images of the sky and horizon from three distant locations were transferred every 30 minutes to a public website for use by the aviation community in assessing current weather conditions at the remote location. The project was an overwhelming success as confirmed by multiple surveys, local and national media releases, and intense interest in the project by both private and governmental agencies.

Objectives

1. Investigate and document the benefits of terrain-based, real-time, imagery collection to enhance intelligence gathering on the battlefield.
2. Investigate imagery sensors (cameras) to enhance the DAMTA system. Specifically enumerate hardware options and methods of employment. Identify best camera systems for inclusion with DAMTA

Proposed Work:

We propose to conduct a complete systems analysis of the integration of imagery sensors on the DAMTA platform. This analysis will include:

1. A research element including:
   a. Exploring the capabilities such a platform will bring to the battlefield in light of the current Future Combat System (FCS) thrust and the benefits that may accrue to peacetime operations. These will include:
      1) Benefits to the aviation community.
      2) Benefits to the intelligence community.
      3) Benefits to maneuver units.
      4) Benefits to other battlefield systems.
      5) Benefits to the meteorology community.
   b. Analyzing the integration of an image sensor into the proposed DAMTA platform given the physical constraints imposed upon the project (air-droppable, self-deploying, disposable etc.)
   c. Evaluating the economic feasibility of adding an image sensor to a disposable platform by comparing it to overall system cost.
   d. Evaluating the vulnerabilities of such a sensor in a harsh, hostile environment.

e. Investigating benefits that may accrue to other governmental agencies employing such a system. Agencies may include the Federal Aviation Administration, National Forest Service and the Environmental Protection Agency.

2. A hardware element including:

   1) Researching available off-the-shelf imagery sensors to determine eligible candidates.

   2) Purchasing feasible systems and evaluating them using multi-objective decision analysis based on evaluation measures deemed critical to the project.

   3) Cold and hot weather testing of selected systems to determine climatic vulnerabilities (as time and schedules permit).

   4) Evaluation of optical clarity of competing systems given their intended use.

Requirements and Milestones:

• Research trip to Alaska	26 May 02
• Problem Definition	1 Sep 02
• Coordination trip to ARL-WSMR	1 Oct 02
• Coordination trip to ATI in CO	15 Oct 02
• Value System Design	1 Nov 02
• Coordination trip to ARL-WSMR	1 Dec 02
• Research trip to CRTC (Cold)	10 Jan 03
• Synthesis of Alternatives	1 Feb 03
• Coordination trip to ARL-WSMR	1 Feb 03
• Research trip to Yuma (Hot)	15 Feb 03
• Systems Modeling and Analysis	15 Feb 03
• Refinement of Alternatives	1 Mar 03
• Research trip to Hawaii (Tropical)	15 Mar 03
• Interpretation of Alternatives	15 Mar 03
• Team Decision Briefing at ARL-WSMR	1 Apr 03
• Prototype Construction	1 May 03
• Final Briefing	8 May 03
• Final Report Complete	15 May 03

Deliverables:

1. A report documenting the findings of this research. Specifically it will enumerate:

   a. Benefits to the Army of terrain-based, real-time, imagery collection to enhance intelligence gathering on the battlefield.

   b. Recommended methods of employment of such a capability (verbiage and drawings)

   c. An assessment of the risks and vulnerabilities of such a system deployed for tactical use in a remote, harsh, environment under varying geographical and climatic conditions.

2. A recommendation of off-the-shelf image sensor(s) currently available for this application.
3. Delivery of a physical prototype (or drawings if design of the platform is not complete) of the selected sensor as it might be employed on the DAMTA.

ORCEN Analyst: None anticipated

Senior Investigator: LTC James M. Buckingham, P.E., Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5181.

Principal Analyst: MAJ Gregory Lamm, M. S., Instructor, USMA-Department of Systems Engineering (845) 938-4792.

Number of Cadets Involved:

a. 1 in Fall 2002 conducting an Independent Study into aspects of this research.
b. 4 in Spring 2003 as part of Engineering Management Capstone Course

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator/Faculty Analyst:

0.65 Man-Years (1 man x 1 year x 0.4 time/year) + (1 man x 1 year x 0.25 time/year)

Total Cadet Time:

0.6 Man-years (1 Cadet x 1/3 year x 1/5 course load) + (8 Cadets x 1/3 Year x 1/5 of total course load)

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

Extended Range Multi-Purpose UAV

Research Project No: DSE-R-0329

Client Organization: PEO Aviation, Redstone Arsenal

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL John D. Burke	Project Manager, Unmanned Aerial Vehicles PEO Aviation Redstone Arsenal, AL	(256)-895-4449	burkejd@tuav.redstone.army.mil
Mr. Alfred R. Reed	ATTN: AMSAM-RD-AS Building 5400 Redstone Arsenal, AL 35898-5000	(256)-313-2408	alfred.reed@rdec.redstone.army.mil

Problem Description:

Perform systems engineering analysis of a proposed extended range multi-purpose UAV. The UAV missions may include small package delivery, communications relay, armed reconnaissance, and strike as well as conventional reconnaissance and surveillance missions.

Proposed Work:

Coordinate with the client to identify highest-priority areas of investigation and develop specific problem statement. Possible areas include:

- automated requirements analysis and threading
- design for maintainability
- human factors analysis and design
- engineering economics
- modeling and simulation
- performance risk tradeoff methodology

Project Deliverables and Due Dates:

- IPRs: 4 Nov 02, 13 Dec 02, Mar 03
- Final Briefing: May 03
- Technical Report: Aug 03

Senior Investigator: Dr. Roger C. Burk, Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-4754

Number of Cadets/Number of Design Teams Involved: CDTs Will Harrison, Thomas Karpuk, and Luke Roberts – SE majors

Supporting Laboratory Technician: Mr. John Melendez, M. A.

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator/Principal Analyst: 136 hours (4 hrs/wk for 2 semesters)

Total Cadet Time: 900 hours (3 cadets for 2 semesters)

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

High Energy Laser Weapons: Modeling and Simulation

Research Project No: DSE-R-0302

Client Organization: High Energy Laser Joint Technology Office (HEL JTO)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Ed Pogue	HEL Joint Technology Office 901 University Boulevard SE, Suite 100 Albuquerque, NM 87106	(505)-248-8200	Ed.pogue@osd.mil
Glen P. Perram Professor of Physics	Department of Engineering Physics Air Force Institute of Technology 2950 P Street Wright-Patterson AFB, OH 45433-7765	(937)-255-3636 ext 4504	glen.perram@afit.edu

Problem Description:

The HEL JTO is coordinating the services' efforts to develop high-energy laser weapons. As part of this effort, the JTO recognized the need for end-to-end modeling of such weapons. Physics-based models exist for laser generation, beam formation and control, atmospheric propagation, and target interaction, but the JTO has no available model for a complete laser weapon shot ("photon birth to death"). Higher-level models of a military engagement, the execution of a military mission, or they carrying out of a campaign involving HEL weapons are also unavailable. It is clear that low-level, very detailed, physics-based models need to be linked in some way to higher-level engagement, mission, and campaign models, but it is unclear how this linkage should be worked.

To fill this gap, the HEL JTO asked the two service graduate schools of engineering (AFIT and NPS) and the three service academies (USMA, USNA, and USAFA) to form a consortium to research what modeling is required and to develop a model or family of models to meet the JTO's needs. AFIT agreed to lead this effort and the other institutions agreed to participate in ways appropriate to their capabilities and areas of responsibility.

The objectives of the effort are: (1) to develop a tri-service research team to integrate DoD fundamental research in end-to-end HEL modeling; and (2) to develop a government-owned, DoD-accepted global interface, which integrates existing and future HEL models. The initial focus must achieve a balance between (1) on-going, high-fidelity technical analyses, (2) engineering trade studies, which allow analyses of a wide range of systems, not simply a deep analysis of any one selected system, and (3) analyses of HEL systems' military utility against a broad range of missions.

The lion's share of the effort will be with AFIT, as the institution with by far the greatest expertise and experience with high energy lasers. The participation of USMA will primarily in evaluating how HELs are or should be modeled in ground warfare and air and missile defense scenarios, and in helping develop linkages from physics-based models to higher-level engagement, mission, and campaign models.

Proposed Work:

USMA will support this effort through the ORCEN and the Photonics Research Center. As a combat modeling center of excellence, the ORCEN will lead the USMA participation. The Photonics Research Center will support with expertise in the area of laser physics.

In consultation with the other particpants, AFIT has defined a three-phase program:

Phase I	(12 months)	Define Modeling and Simulation Architecture
Phase II	(24 months)	Modeling Development
Phase III	(24 months)	Modeling Expansion

This proposal covers USMA contribution to Phase I. This phase comprises the following seven tasks, which are listed with the proposed USMA contributions:

Task 1: AFIT will serve as COTR for JTO M&S Contractual Efforts

(no USMA component)

Task 2: Inventory and Evaluate Existing HEL M&S Capabilities

(a) Examine existing Army engagement and mission models to identify existing HEL modeling capabilities and determine ownership, utility, and limitations

(b) Identify places in existing models where models of HEL weapons would fit

(c) Obtain, execute, and evaluate codes where appropriate

(d) Document existing capabilities and gaps

Task 3: Define and Evaluate Potential HEL M&S Architectures

(e) Research lasers and laser weapons effects to define key modeling parameters for Army applications

(f) Evaluate data aggregation techniques to model HELs in Army engagements and missions

(g) Build simple prototype models to test modeling architecture concepts

(h) Assess candidate M&S architectures for modeling of Army scenarios

Task 4: Define Engagement Scenarios

(i) Define key candidate Army HEL platforms, systems, targets, scenarios, and environmental factors. Consider both offensive and defensive scenarios (attack with HEL, defend against HEL)

Task 5: Select M&S architecture(s) for Phase II development

Task 6: Evaluate potential user interfaces (GUI's)

Task 7: Refine Phase II and III Roadmaps

(j) In conjunction with the other members of the consortium, plan approach to Phase II.

Requirements and Milestones:

- Research trip to Redstone Arsenal, date TBD
- Research trip to White Sands Missile Range, date TBD
- Interim report, December 2002
- Final Phase I technical report, June 2003

Project Deliverables and Due Date:

Technical report giving findings and recommendation for tasks as above, June 2003

Senior Investigator: Dr. Roger Burk, Ph. D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-4754.

Principal Analysts: MAJ Suzanne DeLong, M. S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5537, CPT Eric Tollefson, M.S., Instructor, USMA-Department of Systems Engineering (845) 938-2073, Mr. Paul West, M. S., Instructor, USMA-Department of Systems Engineering (845) 938-5871.

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 150 hours (0.1 person x 0.75 yr x 2000 hrs/yr)

Principal Analyst: 300 hours (0.2 person x 0.75 yr x 2000 hrs/yr)

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: None

Laboratory Technician Hours: None

USMA Directorate of Logistics (DOL) Support

Research Project No: DSE-R-0309

Client Organization: USMA Directorate of Logistics

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
Mr. John Mandia	USMA DOL	(845) 938-7323 DSN 688-7323	yj7755@usma.edu

Problem Description:

The USMA DOL will develop a problem proposal during the summer of 2002. At this time no project description is available.

Proposed Work:

This is a year-long a cadet capstone project satisfying their academic requirements for SE402 and SE403. Research will require cadets to exercise many of the lessons learned in Systems Engineering program and the Core Academic program. It serves as an "integrative experience" for these Systems Engineering Majors.

The cadet design team will formulate several reasonable alternatives to solve a problem for the DOL that will be evaluated, analyzed and presented to the decision maker who may use the results of this analysis to form decisions regarding future improvements and upgrades to existing Academy support operations.

Requirements and Milestones:

- Nov '02: IPR to USMA DOL, outlining initial effort and problem statement.
- Dec '02: IPR to USMA DOL, outlining initial data analysis and proposed alternatives.
- Dec '02: Interim Project Report completed.
- March '03: IPR with USMA DOL: analysis of alternatives results.
- April '03: Final Decision Briefing.
- May '03: Final Capstone Design Report.

Deliverables:

- Multiple IPR's and briefings as desired by the client and suitable to the structure of the cadet research.

- Interim Project Report.
- Final Decision Briefing.
- Final Capstone Design Report.

Analysts: CDT Design Team

Senior Investigator: COL William B. Carlton, P.E., Ph. D., Associate Professor, USMA - Department of Systems Engineering (845) 938-4698

Number of Cadets Involved: 3 to 4

Supporting Laboratory Technician: N/A

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator/Faculty Analyst: ½ year

Total Cadet Time: 6 Credit Hours for each cadet

Lab Use Hours: 0

Laboratory Technician Hours: N/A

Planned Presentations:

- MORS (One cadet/One Faculty member)
- UVA Capstone Conference (two cadets)

Analysis of Value Added by Soldier Tactical Mission System (STMS) Components Utilizing Agent Based Models

Research Project No: DSE-R-0310

Client Organization: PEO Soldier, conducted in concert with and contributing to Soldier Tactical Mission System (STMS) Power Management Study

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Major Jim Smith APM-Power	PEO-soldier Ft Belvoir, VA	DSN 654-3769 (703) 704-3769	James.smith@peosoldier.nvl.army.mil
Mr. Pat Toffler	SY Technologies	DSN 688-8169 (845)938-8169	PatrickToffler@usma.edu
LTC Massie (USMA Power Project coordinator) / Dr Bailey	CME	938-4037 / 938-4105	Darrell.Massie@usma.edu Margaret.Bailey@usma.edu

Problem Description:

Background. Agent Based Models (ABM) are a relatively new class of simulations which have recently been used to model combat. ABMs are based on complexity theory and attempt to treat the simulation entities as semi-autonomous 'agents' who determine their own courses of action based upon preferences. These preferences are inputted as likelihood of acting in certain ways, such as the probability of going towards a friendly agent.

ABMS have the capability of modeling combat in a different way than traditional combat models. In a traditional model the operator must tell the entity specifically where to go, at what speed, and that input can be interpreted as the entities course of action. The entity will then 'fight' enemies with which it encounters. The agent of an ABM decides for itself where to go (again based on preferences), and as it encounters friendly or enemy entities the agent responds by firing, attacking, retreating, passing information, etc. The second significant difference in an ABM from a traditional model is in the way the agent utilizes information. In a traditional model it is possible to collect data from sensors, pass that data to another entity, who stores it. The information can be given to an operator for action (or no action). In an ABM this information is drives the action of the agent – what the agent uses to determine where to go on the battlefield and whether to attack/fire, retreat, etc.

Because of these abilities ABMs have capability of modeling the use of situational awareness, albeit to a limited extent in the current models. Because there is no human-in-the-loop to make decision and drive the simulation we can see what a model does based solely on the information available. A human-in-the-loop analysis is possible with other models, such as IUSS, soldier Station, and Delta Force II, but this same human makes the model slow and fault prone. With an ABM we can replicate a situation many times very quickly and gain insight into the gain from technical improvements (such as sensor range).

The U.S. Army, and in particular, PEO-Soldier, is involved with the individual infantry soldier equipment improvements titled the Soldier Tactical Mission System, presently known as Land Warrior (LW). LW adds capability to the dismounted soldiers on many levels, the most significant being in the areas of Lethality, C4I, Protection, Sustainability, and Mobility. There are a number of components that make up this ensemble – we will focus on the 21 components that require electrical power to operate. Power management is an enabler that will allow the STMS to function in combat. TSM-Soldier is currently conducting an Analysis of Alternatives in which they are modeling the value added of the LW components. This project will seek to augment that work but will focus on not only determining the value added by the components, but will seek a relative order of merit of these components in order to bolster research into power management.

Problem: Determine the relative merit of STMS components utilizing ABMs.

Assumptions:

1. LW component power demands are known or estimated (based on CME research).
2. Optimal management of power will depend on required situational awareness and knowledge of changing priorities.

Objectives:

Determine a relationship between components that can be used to specify when and how power should be used, (e.g. What components must be on? Which can be off? When must the components be on or off? What components can be on standby and when? What types of missions require the components to be on, standby or off? Who needs to have full power to the component? Are the answers to these questions different for leaders and soldiers?)

Proposed Work:

The primary emphasis will be on the Land Warrior System v1.0. The proposed organization will be the squad. Application to the OFW and FCW will be investigated if time is available.

1. Problem definition:
   - Conduct literature searches and background studies
   - Develop engineering problem statement
   - Develop value system
   - Conduct research into which ABM is more appropriate for this analysis
2. Design and Analysis:

- Develop the scenario vignettes that will be used in the analysis. Scenario vignettes will be as close as possible to those used in co-study on power management
- Model and analyze alternatives using Agent Based Models, specific model TBD
- Conduct a comparison of output of this methodology to that of the co-study in power management utilizing more traditional combat models
- Comment on the validation of ABMs as an aspect of this study

Requirements and Milestones:

Milestone	Date
Background Research	16 Aug – 13 Sep August 02
Needs Analysis & Value System Design	13 September 02 – 20 September 02
Model exploration and determination	20 - 30 September 02
Analysis of Alternatives (conduct modeling)	1 October - 8 November 02
Draft report completed	22 November 02
Final Briefing	13 December 03
Technical Report Completed	31 January 03

Project Deliverables and Due Date:

A technical report documenting the findings of this research. Specifically it will:

- Determine minimal power demand for each mission type. Specify which components must be on/off/standby.
- Determine minimal power demand for missions with degraded power source given a 12 hour mission duration, and specify under what circumstances components should be on/off/standby.
- Compare the output of the ABM to other studies being conducted. Utilizing this comparison comment on the validation of Agent Based Models.

Senior Investigator: COL William B. Carlton, P.E., Ph.D., Associate Professor, USMA – Department of Systems Engineering (845) 938-4698

Faculty Analyst(s): LTC Stephen Horton, Ph.D., Assistant Professor, USMA – Department of Mathematical Sciences (845) 938-5905, LTC Darrell Massie, Associate Professor, USMA – Department of Civil & Mechanical Engineering (845) 938- 4037.

ORCEN Analyst: MAJ David Sanders, M.S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5539

Number of Cadets/Number of Design Teams Involved: CDT Scott Womack

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator:	0.02 man-years
Principal Analysts:	.125 man-years (10 hours/week for 26 weeks)
Lab Technician:	0.01 man-years
Total Cadet Time:	0.05 man-years (6 hrs week for 17 weeks)
Total:	.205 man-years

Lab Use Hours: 3 hour/week (51 hours/year)

Laboratory Technician Hours: 0.5 hours/week (20 hours/year)

Accelerating the Hungarian Algorithm for Transportation Problems

Research Project No: DSE-R-0306

Problem Description:

The classical assignment problem is to assign n jobs to n machines at the least total cost. This paper presents a modification to Kuhn's Hungarian Method that explicitly maximizes the underlying dual ascent obtained at each step. The modification is both simple and insightful.

Since its introduction by Kuhn (1955), there have been only a small number of improvements to the Hungarian algorithm for solving the classical assignment problem given by

$$\text{Minimize } \sum_{i=1}^{n}\sum_{j=1}^{n} c_{ij}x_{ij} \tag{1}$$

$$\text{subject to: } \sum_{j=1}^{n} x_{ij} = 1, \quad i = 1,\ldots,n, \tag{2}$$

$$\sum_{i=1}^{n} x_{ij} = 1, \quad j = 1,\ldots,n, \tag{3}$$

$$x \geq 0. \tag{4}$$

The solution to the assignment problem (1)-(4) yields a minimum weighted perfect matching between the n jobs and n machines. Wright (1990) notes that although one might posit that simplicity requires no improvement, when a long series of successive assignments needs to be made (Wright, 1989), or such assignments appear as a sub-problem to much more difficult problems (Hahn et al., 1998), even minor gains in computational efficiency can yield significant overall savings. Barring such improvements, researchers will turn to other algorithms to achieve efficacy. The labeling algorithm introduced by Lofti (1989) and the dual update method of Ping et al. (1997) are prime examples of this effect. The modification we propose is motivated by a desire to maximize the underlying dual ascent that is implicit during each iteration of the algorithm.

Proposed Work:
Coding and computational testing of the proposed modification.

Requirements and Milestones: TBD

Project Deliverables and Due Date:

Technical Report: January, 2003

Senior Investigators: Dr. Patrick J. Driscoll, Ph.D., Professor, USMA – Department of Systems Engineering, Dr. Hanif D. Sherali, Ph.D., P. E., W. Thomas Rice Endowed Chaired Professor of Engineering, Grado Department of Industrial and Systems Engineering, Virginia Tech.

Faculty Analyst(s): None

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None.

Resources Required for Project:

Research Hours Required (by position):

Principal Investigator: 40 Hours

Principal Analyst: 0 Hours

Lab Technician: 0 Hours

Total Cadet Time: 0 Hours

Lab Use Hours: None

Laboratory Technician Hours: None

A Design Space Branching Methodology for Systems Design for Redundancy

Research Project No: DSE-R-0307

Problem Description:

In the study, we develop a mathematical programming based branching strategy for designing reliability redundancy into systems that uses a new fathoming heuristic we developed that exploits both the discrete nature of the system reliability function and the variation contained in component reliability estimates to reduce the total design space. Current methods either directly face the extreme nonlinearity of the system reliability function or attempt to employ branching strategies directly on the decision variables without considering the inherent variation contained in the reliability estimates.

Proposed Work:

- Examine the computation efficiency of design space branching on large-scale problems.
- Develop a new linearization strategy for the system reliability function that introduces a totally unimodular (TU) substructure into the linear constraints defining the problem.
- Determine the computational efficiency of the linearization strategy, exploring the options for tightening the polyhedral representation of the convex hull of the design space variables.

Requirements and Milestones:

- Follows the proposed work above.

Project Deliverables and Due Date:

- Presentation of results at RAMS and ORS in 2003 (see budget worksheet).
- Technical Report: August, 2003.

Senior Investigators: Dr. Patrick J. Driscoll, Ph. D., Professor of Operations Research, USMA-Department of Systems Engineering (845) 938-6587, Lt. Col. Edward Pohl, Ph. D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206

Faculty Analyst(s): None.

Number of Cadets/Number of Design Teams Involved: None.

Supporting Laboratory Technician: None.

Resources Required for Project:

Research Hours Required (by position):

Principal Investigator: 100 Hours

Co-Principal Investigator: 100 Hours

Lab Technician: Hours

Total Cadet Time: Hours

Lab Use Hours: None.

Laboratory Technician Hours: None.

Planned Presentations:

- INFORMS Annual Conference, San Jose, CA, November 17-20, 2002.
- The Annual Reliability and Maintainability Symposium (RAMS), Tampa, FL, January 27 –30, 2003.
- The 45th Conference of the Operational Research Society (ORS), UK, Sep 2003.

Modeling the Decision Quality of Sensor-to-Shooter Networks

Research Project No: DSE-R-0308

Problem Description:

This study presents a methodology for representing the decision quality of STS networks involving unattended ground sensors (UGS) in terms of the uncertainty associated with the network information flow. Understanding the limitations imposed by this uncertainty provides design guidance for precision levels and information maintenance strategies that will improve the accuracy of the information used at various decision points in an STS network, including the fire/no-fire decision point.

Proposed Work:

- Examine the quality of the information products manufactured by the devices and processes of a sensor network.
- Develop an information-based framework for assessing the decision quality of STS networks in terms of the uncertainty present at decision points.
- Develop metrics for sensitivity and analyze the sensitivity of STS networks to changes in uncertainty to develop prioritized information maintenance plans.
- Prescribe investment guidelines for precision based on diminishing marginal returns to the level of uncertainty at critical decision points in an STS network.
- Better understand the uncertainty 'comfort zone' used currently for decision making.
- Prescribe guidelines for threshold decision criteria for fully-automated STS networks.

Requirements and Milestones:

In chronological order, we plan to undertake the following.

FY 2002:

1. Develop a new representation of a general support STS network within an information manufacturing framework based in part on the taxonomy of uncertainty introduced by Smets (1991, 1997), and the information quality decomposition of Eppler (2001) and Wang (2001). We adopt a systems engineering perspective in this vein, seeking to identify the critical functions that must be performed by any STS network. (DONE)
2. Using this framework, we introduce a new definition of decision quality based on the percentage of uncertainty present at a decision point independent of the actual decision made, thereby uncoupling process outcome from action outcome. This definition of decision quality then allows us to decompose an STS network in terms of the probability distributions associated with processes and parameters throughout the network. (IN PROGRESS)

3. Using the design guidelines for effective number of unattended magnetic ground sensor (UGS) cluster developed by Lamm and Driscoll initially, we then will characterize important performance distributions involved with the sensor functions (detect, classify, operate, identify), and the algebraic operations that manipulate these distributions in the process of manufacturing information. (TO DO)

4. Next, we develop closed form analytical expressions for the distributions associated with aggregating sensors, the master node voting (k out of n) process, intermediate information products (IIP), and the final information product present at the decision point(s). (TO DO)

5. Using the closed form expressions for distributions, we will then analyze the sensitivity of various statistical parameters describing the decision point distribution (the uncertainty involved with the decision point) to changes in number of sensors, mix of sensors, and precision levels of sensor functions. These results will then be integrated with the sensor performance tradeoff function results obtained by Lamm and Driscoll (2002) in order to propose equivalence measures and points of diminishing returns with regards to device precision and response levels of uncertainty. (TO DO)

6. Building on the stochastic network constructed previously, we then state the implications for future research and development on sensor precision and quantify the marginal benefits of performing specific information maintenance actions at various locations throughout the network. We additionally provide guidelines as to the goals that such activities should seek.

FY 2003:

7. We next examine the sensitivity of the decision quality as it responds to changes in the k-out-of-n voting process of the master node to identify and prescribe ideal design guidelines.

8. Building on the sensitivity results obtained as indicated, we propose to create a Raptor or MODSAF simulation to compare the analytical results obtained to numerical results in the simulation environment. We will then perform standard data analysis to identify critical factors affecting design issues. It is at this stage that we propose to validate our results with the performance statistics of actual sensor clusters at the Night Vision Laboratory's test center.

9. Using the framework developed in (1)-(8) above, we apply the same methodology to each homogeneous sensor cluster type in succession: acoustic, seismic, thermal (IR).

10. We next modify the simulation to include the effects of weather and perform a sensitivity analysis on the Decision Quality in context of these effects.

11. Next, we propose to examine the feasible combinations of sensor types in an n-sensor cluster environment as to their effect on the decision quality at the fire/no fire point of the STS network. We seek to identify high performance combinations of sensor types that simultaneously minimize the amount of uncertainty present at the decision point. The results of this effort will be used to prescribe TOE and general sensor cluster composition guidelines based on decision quality.

Project Deliverables and Due Date:

- Presentation of results at ICIQ-02 and MORSS 2003
- Technical Report: August, 2003

Senior Investigators: Dr. Patrick J. Driscoll, Ph. D, Professor of Operations Research, USMA-Department of Systems Engineering (845) 938-6587, Lt. Col. Edward Pohl, Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206

Faculty Analyst(s): None.

Number of Cadets/Number of Design Teams Involved: None.

Supporting Laboratory Technician: None.

Resources Required for Project:

Research Hours Required (by position):

Principal Investigator: 100 Hours

Co-Principal Investigator: 100 Hours

Lab Technician: Hours

Total Cadet Time: Hours

Lab Use Hours: None.

Laboratory Technician Hours: None.

Planned Presentations:

- The 7th International Conference on Information Quality (ICIQ-02), 8-10 NOV 2002, Cambridge, MA
- 71st MORS Symposium, Marine Corps Base Quantico, Quantico, Virginia, 10-12 June 2003

Modal Logic and Sensor Information Fusion

Research Project No: DSE-R-0317

Problem Description:

A Sensor-to-Shooter (STS) network is a closed-loop, internal feedback targeting system that links various suites of sensors deployed throughout a 3D battlespace to a network of weapons platforms using optimized communications pathways. A fully-automated STS network can be decomposed into three major segments: target acquisition, a fires commitment decision process, and a weapons engagement process. Targets are detected, classified and identified at the sensor end of the network. A decision support system then determines if threshold criteria for target identification has been met, and if so, makes the decision to commit the appropriate available weapons platform(s) to engage the target. Once handed the fire mission, the weapons platform would engage the target, the sensors would assess the damage, the decision support system would again compare target damage to threshold criteria, and re-engage as necessary.

Designing such a system for general support of operational forces is tricky business. Success is intricately tied to exactly how acceptable firing thresholds are determined and imbedded in fully-automated STS networks. These thresholds need to be dynamically adaptable to changing battlespace conditions that dictate the mode of threshold control that should be in force.

In this study, we propose to develop new guidelines for fully-automated fire/no fire STS thresholds using a framework of probabilistic Modal Logic, and evaluate this approach using both prepositional Kripke and Bayesian network models. We introduce the notion that a battlespace can be completely characterized by a finite set of what we call enemy operational states (EOS). Exactly which EOS the battlespace is in, or will be in the near future, can be probabilistically determined using the magnitude of associated key descriptors (KD) whose levels are directly affected by sensor information input. Because knowledge of an EOS directly conveys enemy intent, the results of this study should provide meaningful insights toward resolving outstanding information fusion issues associated with STS networks. Moreover, by determining appropriate sets of key descriptors (KD) in the fashion described, that also have a set of desirable mathematical properties, we can obtain valuable insights as to what "symptoms" of the battlespace sensors should be designed to detect. We acknowledge up-front that these might not be the traditional ones designed for sensing in the existing suites of battlespace sensors.

The underlying principle of our approach is the belief that sensor information leading to the conclusion "true" while the battlespace is in one enemy operational state (EOS) is not necessarily "true" for a different EOS. There are degrees of state that condition truth statements in the battlespace. This means that the level of acceptable evidence concerning a potential target in one EOS can be dramatically different from that of another EOS. We therefore posit that if an STS system is to have preset levels of target acceptability thresholds, that

(a) these thresholds must be capable of being directly determinable from KDs whose levels are determined from pure sensor information;

(b) the STS fire/no fire decision system must be capable of switching between control modes corresponding to different EOS; and

(c) the target confirmation acceptability thresholds must explicitly align with the rules of engagement in force.

Objectives

1. Develop a new modal logic framework for determining threshold settings for acceptability of battlespace truths that permit sensor to shooter (STS) target engagements.
2. Investigate the effectiveness of this framework as implemented in computational software.

Proposed Work:

We propose to study the construction of a new framework for STS networks capable of providing guidelines concerning target acceptance thresholds for fully-automated STS networks. This study will include, but is not limited to:

1. A research element including:
   - A computational and theoretical comparison of Modal Logic to other methods to reason about uncertainty in the FCS Information Fusion Framework. The comparative methods include, but are not limited to:
     1. Bayesian Belief Networks
     2. Fuzzy Logic
     3. Expert Systems
        - Using modal logic to reason about truth values at various levels of the network information flow framework. Use Modal Logic to illuminate those KD's that support other EOS's other than a dominant EOS. This might help identify deception and also selection of efficient KD sets.
        - Combining elements of graph theory and Modal Logic to help identify a potentially optimal set of key descriptors, and developing strong metrics for associating the levels of specific descriptors with specific EOS's.

Requirements and Milestones:

• Research coordination meeting (West Point)	Nov 02
• Research trip to Arizona	Dec 02
• Research trip to Arizona	Feb 03
• Preliminary Paper on new framework	Feb 03
• Masters Thesis Complete	May 03

- Final Briefing May 03
- Final Report Complete July 03

Deliverables:

1. A technical paper documenting the findings of this research.
2. A Masters Thesis for the University of Arizona.

ORCEN Analyst: None anticipated

Senior Investigator: Dr. Patrick J. Driscoll, Professor of Operations Research., USMA-Department of Systems Engineering (845) 938-6587.

Co-investigator: CPT Steven Henderson, Department of Systems & Industrial Engineering, University of Arizona, Tucson, AZ 85721, (520) 621-6551.

Number of Cadets Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator/Co-investigator Analyst: 1.0 Man-Years

Total Cadet Time: 0

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

Modeling Corrosion from Eddy Current Non-destructive Tests

Research Project No: DSE-R-0314

Client Organization: Department of Systems and Information Engineering, University of Virginia & USAF Research Laboratories, Wright- Patterson AFB, OH

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Donald E. Brown, PhD *(PhD Advisor)*	Department Chair, Department of Systems and Information Engineering, University of Virginia	804-982-2074	brown@vriginia.edu

Problem Description: (Dissertation Research for PhD in Systems Engineering)

This research will develop an aircraft corrosion and classification model. Quicker, more effective methods of corrosion prediction and classification will help ensure an operationally ready aircraft fleet capable of conducting military operations worldwide. This is especially critical now, as the armed forces strive to meet the increased expense of repairing aging aircraft with a dwindling budget.

These budget constraints make it imperative to correctly determine the appropriate time to replace corroded parts. If the part is replaced too soon, the result is wasted resources. However, if the part is not replaced soon enough, it could possibly cause a catastrophic accident. The development of a model that limits the possibility of a costly accident while optimizing resource utilization would allow the military to efficiently focus its maintenance and budgetary efforts. This model would not only be useful to the military but could also apply to civilian aviation or other vehicles prone to corrosion damage. The goal of this research is to explore the framework of such a modeling tool.

Proposed Work:

- Research and Evaluate several modeling methods
- Try to improve upon best performing algorithm use theoretical hypotheses and testing
- Create a useful program that either enhances or replaces current methods of corrosion identification

Requirements and Milestones:

- Research (Fall 01 – Fall 02)
- Write and present proposal to University of Virginia (Fall 02)
- Create algorithm using programming language (Fall 02 – Spring 03)

- Conduct Theoretical tests on new algorithm and validate model (Spring 03-Fall 04)
- Write-up findings and defend dissertation (Fall 04 –Spring 04)

Project Deliverables and Due Date:

- Dissertation Proposal (Fall 02)
- Dissertation Defense (Spring 04)
- Dissertation Write-up (Spring 04)

Senior Investigator: Dr. Patrick J. Driscoll, Ph. D., Professor of Operations Research, USMA-Department of Systems Engineering (845) 938-6587

Faculty Analyst(s): CPT(P) John Brence, M. S., Instructor, USMA-Department of Systems Engineering (845) 938-5535

Number of Cadets/Number of Design Teams Involved: 0.

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 100

Principal Analyst: 1000

Lab Technician: 0

Total Cadet Time: 0

Lab Use Hours: 0

Laboratory Technician Hours: 0

Air Warrior Comanche

Research Project No: DSE-R-0305

Client Organization: Operational Test Command (OTC)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL Alton McKennon	Operation Test Command (OTC) Aviation Test Directorate Ft. Hood, TX	254-288-9992	McKennonAlton@otc.army.mil
Mrs. Dawne Patterson	Operation Test Command (OTC) Aviation Test Directorate Ft. Hood, TX	DSN: 738-9612	PattersonDawne@otc.army.mil

Problem Description:

The problem is to determine a general hypothesis testing tool that can be used as a one procedure handles most cases of single hypothesis testing and can also handle censored data. The power requirements of the test are to exceed standard tests in use such as the Anderson-Darling goodness of fit test and its modification.

Proposed Work:

Investigators will use the software tool APPL to develop a general theory that can be computed exactly. The methodology developed will be tested using the simulation capability of APPL.

Requirements and Milestones:

A set of three papers is to be written to describe and define the methodology. Data from OTC will be analyzed to demonstrate the procedure. A turnkey front end will be developed to allow non-technical users to use the procedure in testing problems involving Air Warrior and Comanche.

Project Deliverables and Due Dates:

Complete manuscripts and deliver software:	May 1, 2003
Step 1: Review procedures, experiments and data given by OTC.	Oct 1, 2002*
Step 2: Select some procedures and test new approaches and general use of new methodology.	Nov 1, 2002*
Step 3: Report results of analysis. Benefits, costs, dollar savings	Dec 2, 2002*
Step 4: Complete specifications for the new software	Feb 1, 2003*
Step 5: Specify new experimental design procedures	April 1, 2003*

Step 6: Software aids provided and manuscripts submitted May 1, 2003*

Special task: Define a cadet capstone experiment that requires use of new software.

**To be determined (TBD)*

Senior Investigator: Dr. Bobbie Foote, Ph. D., Professor, USMA-Department of Systems Engineering (845) 938-4893, CPT Marie L. Hall, M. S., Chief, Institutional Research, USMA-Installation Research & Analysis Branch, Office of Policy, Planning & Analysis (OPA) (845) 938-7389

Principal Analyst(s): LTC Andrew Glen, Ph. D., Assistant Professor, USMA–Department of Mathematical Sciences (845) 938-5988

Number of Cadets/Number of Design Teams Involved: 2 Cadet Teams - TBD

Supporting Laboratory Technician: None

Resources Required for Project*:*

Research Hours Required (by position):

Senior Investigator: 8 hours/week (Dr. Foote)

Principal Analyst: None

Lab Technician: None

Total Cadet Time: 6 hours/cadet/week – one semester

Lab Use Hours: None

Laboratory Technician Hours: None

Analysis of Reliability When Data is Masked

Research Project No: DSE-0330

Proposed Work:

It is proposed that the problem of determining the values of sub-system elements when only the output of the system is known is to be explored. This problem is being re-explored because of the emergence of two tools that have been developed in the last ten years. These tools are APPL, a probability modeling language, and a new method based on bootstrapping to solve stochastic linear programs with recourse. APPL allows for the first time for a circuit consisting of series and parallel elements the computation of the exact pdf of the reliability of the circuit. A stochastic linear program with recourse model allows for the possibility that subsystem parameters can be estimated from life testing data.

Requirements and Milestones: Design of an optimization package based on the theories developed by Dr. Bobbie Foote

Project Deliverables and Due Date: TBD

Senior Investigators: Dr. Bobbie Foote, Ph. D., Professor, USMA-Department of Systems Engineering (845) 938-4893, Lt. Col. Edward Pohl, Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206, LTC Andrew Glen, Ph. D., Assistant Professor, USMA–Department of Mathematical Sciences (845) 938-5988.

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 160

Principal Analyst: 320

Lab Technician: None

Lab Use Hours: N/A

Laboratory Technician Hours: N/A

Disposable Sensor Operational Characteristics

Research Project No: DSE-R-0335

Client Organization: Sensor and Electronic Device Directorate, Army Research Laboratory

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Mr. John Eicke Signal and Image Processing Division, Sensors and Electronic Device Directorate, Army Research Laboratory	ATTN: AMSRL-SE-S 2800 Powder Mill Rd Adelphi, MD 20783-1197	(301) 394-1553	jeicke@arl.army.mil

Problem Description:

The Objective Force will employ sensors to enhance operational capability. Disposable sensors (DS), defined as costing less than $10 per sensor, appear to be attractive. However, disposable sensors provide reduced capability over sensors that are more expensive. This research will examine the trade offs required for disposable sensors and the operational impacts.

As the parameters of the fielded sensors is not yet known, estimated parameters will be determined in coordination with the Signal and Image Processing Division, Sensor and Electronic Device Directorate, the Army Research Laboratory. This research effort will provide an initial analysis of the benefits and drawbacks of disposable sensors, attempt to establish performance criteria, and develop methodology that may be employed in future work when sensor performance specifications have matured.

Problem: Examine the impact of employment of disposable sensors.

Objectives:

1. Capture likely performance characteristics of disposable and nondisposable sensors.
2. Assess the operational benefits of sensor fields with disposable sensors, nondisposable sensors, and a mixture.
3. Determine conditions under which it is beneficial to use Disposable Sensors.

Proposed Work:

3. Problem definition.
    - Conduct literature search to:
        i. Establish anticipated sensor performances,

    ii. Establish anticipated senor employment doctrine.

- Articulate assumptions.

4. Design and Analysis
    - Develop the scenario that will be used in the analysis.
    - Model and analyze alternatives using a simulation model, specific model TBD.

5. Results
    - Establish what characteristics are traded away to gain the less expensive disposable sensors.
    - Determine, if possible, the relative effectiveness of employment of disposable sensors, nondisposable sensors, and mixtures of the two types.

Requirements and Milestones:

Milestone	Date
Background Research	16 SEP – 28 OCT 02
Configuration & Methodology Definition	28 OCT – 12 NOV 02
Scenario Section/Definition	12 NOV – 2 DEC 02
Analytic Tool Selection/Analyst Self-education	2 DEC 02 – 18 JAN 03
Analysis of Alternatives	18 JAN – 18 FEB 03
Draft Report Completed	3 MAR 03
Final Briefing	TBD (anticipated for APR 03)
Technical Report Completed	28 APR 03

Project Deliverables:

A technical report documenting the findings of this research. Specifically it will:

- Compare advantages and disadvantages of disposable sensors.
- Attempt to discuss cost effectiveness of disposable sensors.

Senior Investigator: COL William K. Klimack, PhD, Associate Professor & Director, Operations Research Center (ORCEN), USMA – Department of System Engineering (845) 938-5529.

Faculty Analyst(s): MAJ David Sanders, M.S., Assistant Professor and ORCEN Analyst, USMA-Department of Systems Engineering (845) 938-5539.

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator:	TBD
Principal Analyst:	TBD
Lab Technician:	TBD
Total Cadet Time:	TBD
Total:	TBD

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

Bradley Fighting Vehicle Main Weapon System Upgrade

Research Project No: DSE-R-0316

Client Organization: PM Bradley

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL Curtis McCoy	PM Bradley	804-586-5318	mccoyc@tacom.army.mil

Problem Description:

The Bradley Fighting Vehicle and associated variants will continue to be employed in the legacy force for several decades. It is expected that enemy armored vehicles will continue to upgrade their defensive armor as technology becomes available. The M242 25mm "Bushmaster" chain-gun currently mounted as the primary weapon system for the Bradley may become obsolete due to this advanced armor protection.

PM Bradley is currently exploring alternatives for upgrading the weapon system which may or may not include additional ammunition capabilities. Weapons to be considered must be fully developed, commercially available, and provide enough enhancement to the current vehicle capabilities as to last a significant amount of the Bradley's remaining useful life.

Proposed Work:

USMA will support this effort through junior faculty research and weapon systems modeling in the Combat Simulation Lab (CSL). The CSL will allow modeling of BFVs equipped with the proposed system(s) in a JANUS environment and data collected on simulated combat performance. The modeling will be conducted as an exercise in the SE485 Combat Modeling course by the cadets enrolled during the spring semester.

Requirements and Milestones:

- Research trips to PM Bradley, date TBD
- Research trips to Aberdeen Proving Grounds, date TBD
- Interim report, December 2002
- Final initial technical report, June 2003
- Follow-on Cadet AIAD, Summer 2003

Project Deliverables and Due Date:

- Technical report giving findings and recommendation, June 2003

Senior Investigator: COL William K. Klimack, Ph. D., Associate Professor & Director, Operations Research Center, USMA-Department of Systems Engineering (845) 938-5529

Principal Analysts: MAJ Richard V. Petitt, M.S., Instructor, Department of Systems Engineering (845) 938-4756, MAJ Suzanne DeLong, M. S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5537

Number of Cadets/Number of Design Teams Involved: TBD

Supporting Laboratory Technician: Mr. John Melendez, M. A .

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 150 hours (0.1 person x 0.75 yr x 2000 hrs/yr)

Principal Analysts: 300 hours (0.2 person x 0.75 yr x 2000 hrs/yr)

Lab Technician: 75 hours (0.05 person x 0.75 yr x 2000 hrs/yr)

Total Cadet Time: As determined by SE485 Course Director

Lab Use Hours: As determined by SE485 Course Director

Laboratory Technician Hours: None

Evaluating the Effectiveness of Interactive Multimedia Instruction for Soldier Tactical Mission Systems

Research Project No: DSE-R-0320

Client Organization: Project Manager-Soldier Systems

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL Theodore Johnson Project Manager PM-Soldier Systems	10125 Kingman Rd. Room 127 Ft. Belvoir, VA 22060-5852	DSN 654-3816 (703) 704-3816	tjohnson@pmsoldier.belvoir.army.mil Fax (703) 704-1951
Mr. Ellis A. Mosely Chief, Research and Development Logistics, Readiness Management Division PM-Soldier Systems	10125 Kingman Rd. Room 127 Ft. Belvoir, VA 22060-5852	DSN 654-3862 (703) 704-3862	emosely@pmsoldier.belvoir.army.mil Fax (703) 704-1951

Background:

Computer Based Training (CBT) has emerged as potentially a more cost effective and efficient education and training vehicle than traditional methods. In particular, Interactive Multimedia Instruction (IMI) is a much more engaging means of presenting course Programs of Instruction (POI). Interactive multimedia instruction is typically defined broadly in education as employing computer systems to deliver instruction that employs a combination of several media, which may include sound, text, video, computer graphics, and animation. For this research, the definition includes simulation.

The literature shows mixed results with respect to IMI effectiveness in various arenas, both within and outside the armed forces. However, many in the field contend that, with the appropriate combination of task selection and level of presentation, IMI can add significant value in terms of knowledge retention and performance. The military can benefit from the outstanding technological improvements in CBT and web-based instruction. In order to fully harness this technology, however, the selection of tasks to be converted and presented via IMI must be accomplished with appropriate consideration.

The process of IMI selection should examine the nature of certain blocks of instruction, as well as appropriate levels of interaction between the student and courseware. The metrics must reflect successful task accomplishment in terms of proficiency and time required to train, as well as establish measures for the desired level of simulation presentation, where applicable. In addition, the concepts of reuse and adherence to a higher-level architecture must also be considered.

Although this project will use IMI development for military science education with course MS102C, Ground Maneuver Warfare I, as the case study, the methodology for IMI evaluation will be readily applicable across the spectrum of education and training scenarios inherent to Soldier Tactical Mission Systems (STMS) fielding—new equipment training (NET) and sustainment training.

Problem Description:

The overall goal of this project is to study the use and effectiveness of IMI for military training and education in general and for the STMS in particular. The research question will be examined within the framework of military science education at the U.S. Military Academy (USMA). Corollary research will investigate the merits of integrating IMI as part of an Advanced Distributed Learning (ADL), or distance learning, prototype for USMA and military units.

Proposed Work:

The Operations Research Center of Excellence will execute the second year of a multi-year research project as follows:

1. Continue to survey the body of knowledge for successful employment of IMI to other tested combat systems. Examine both military and civilian resources for empirical evidence that quantifies the overall effectiveness of IMI and in both education and training.
2. Evaluate the MS102C – Ground Maneuver Warfare I POI for task(s) that are most translatable to a web-based IMI format.
3. Assist in the conceptual development of IMI storyboards that support the tasks to be evaluated. Assist DMI and PM-Soldier, as required, ensuring that the IMI product source (contractor) produces the IMI to the appropriate level of fidelity consistent with TRADOC Pam 350-70-5 – Multimedia Courseware Development Guide.
4. Conduct an experiment to examine the cognitive effects of various levels of IMI educational material for military topics. The experiment will be executed during the USMA Military Intersession, January 2003.
5. Develop an IMI assessment methodology to assess training tasks with respect to the benefit of employing IMI. It is anticipated that the methodology would separate tasks into two categories: tasks that may be more efficiently taught using IMI and those for which IMI adds no efficiency.
6. Develop a software assessment methodology, to include definition of metrics and development of an evaluation framework, for commercial-off-the-shelf (COTS) games that can be reengineered for applications as military simulation software.

Summary:

STMSs are being developed to enhance the individual soldier's survivability, lethality and overall combat effectiveness on the battlefield. PEO Soldier has developed a STMS suite that is in the early stages of developmental testing (DT) now. As the STMS versions will change throughout the system's life cycle, the training framework and accompanying training devices will likely evolve as well. We feel that IMI offers great potential in increasing the efficient use of training time and therefore is a valuable contribution to the comprehensive training plan for the fielding of STMSs. Practical execution is obviously the best method for meeting certain educational and training objectives. Likewise, traditional preparation and conventional lecture techniques may be the most appropriate method of teaching others. IMI with simulation may be viewed as the bridge between these two methods.

IMI courseware for MS102C will be developed for tasks that support land navigation. The IMI will be employed within an instructional framework such that certain subsets of the cadet population of the Class of 2006 will receive specified IMI packages. The instructional and test plan will generate data that will allow evaluation of the effectiveness of the IMI with respect to cadet retention of knowledge and techniques, as well as performance on a practical exercise using PC-based virtual desktop simulation.

As stated earlier, conventional courses may be converted in part or in total to web-based instruction. USMA, other US Army organizations, and many of our NATO allies are considering the efficacy of this transition. USMA provides an ideal test bed for an IMI pilot program, as the Academy is continually focused on transforming the collective academic program by employing new technologies. We will evaluate the effectiveness of IMI to educate cadets on a subset of military tasks and will estimate the effectiveness of IMI employed to educate and train STMS-equipped soldiers and units.

Senior Investigator: COL William K. Klimack, Ph. D., Associate Professor & Director, Operations Research Center, USMA-Department of Systems Engineering (845) 938-5897

Principal Analyst: MAJ Christopher M. Farrell, B. S., Instructor & ORCEN Analyst, USMA-Department of Mathematical Sciences (845) 938-5661

Global Combat Support System-Army Analytic Support

Research Project No: DSE-R-0322

Client Organization: Program Manager Global Combat Service Support System – Army

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL Stephen E. Broughall, Jr.	PM GCSS-ARMY ATTN:SFAE-PS-RS 800 Lee Avenue Fort Lee, Virginia 23801 http://www.gcss-army.army.mil/PMGCSS-ARMY.htm	(804) 734-7665	broughalls@lee.army.mil
MAJ Pat Flanders	Project Manager Global Combat Support System Army ATTN: SFAE-PS-RS (MAJ Pat Flanders) 800 Lee Avenue Fort Lee, VA 23801-1718	W: (804) 734-6181 C: (804) 691-1607	flanderst@lee.army.mil

Problem Description:

The GCSS-A system will provide a common IT systems for all Army logistics and administrative functions. The concept of Enterprise Resource Planning (ERP) approaches has become popular in the private sector in recent years. ERPs provide a centralized database and business rules to leverage information utilization. Private sector organizations have realized significant returns on investment with ERPs. However, most ERP implementations fail despite high levels of effort and funding. Even ERP successful implementations were typically preceded by a failed, expensive attempt at even the most cutting edge IT companies. Additionally, commercial ERPs assume communications will be available. The tactical Army is faced with severely constrained communications. The GCSS-A program is being considered for conversion to an ERP approach.

Proposed Work:

This research effort is a continuation of work performed during Academic Year 2001-2002. It is anticipated that research will refine previous work, as required to support an Army decision for GCSS-A. A decision analysis value focused thinking-based value model previously constructed by the Operations Research center of Excellence will be improved as required to provide refined analytic capability in support of PM GCSS-A. Improvements may take the form of improved fidelity in preference function modeling, refined relative importance of criteria, extensions of sensitivity analyses, and modification of alternative descriptions and scorings, as required. As in the previous year, reviews of other aspects of the decision may be provided as requested by PM GCSS-A. ORCEN personnel will participate in PM GCSS-A planning and evaluation sessions as requested by the PM.

Project Deliverables and Due Dates:

- Interim IPRs: As requested by PM GCSS-A.

- Final Briefing: April 2001.
- Technical Report: April 2001.

Senior Investigator: COL William K. Klimack, Ph. D., Associate Professor & Director, Operations Research Center, USMA-Department of Systems Engineering (845) 938-5529

Number of Cadets/Number of Design Teams Involved: None anticipated.

Supporting Laboratory Technician: None anticipated.

Resources Required for Project:

Research Hours Required (by position):

Principal Analyst: TBD

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: None

Laboratory Technician Hours: None

Installation Risk and Vulnerability Assessment Tool

Research Project No: DSE-R-0319

Client Organization:

Sponsor: Assistant Secretary of the Army (Financial Management & Comptroller) (ASA FM&C)

User: Assistant Chief of Staff for Installation Management (ACSIM)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Ms. Sharon Weinhold	Acting DASA for Resource Analysis and Business Practices SAFM-RB	DSN 222-7399 (703)692-7399	Sharon.Weinhold@ hqda.army.mil
Ms. Mary Engoglia	Financial Management Analyst DASA (Resource Analysis and Business Practices) SAFM-RB	DSN 222-7400 (703)692-7400	Mary.Engoglia@ hqda.army.mil
Ms. Linda Smith	HQDA ISR/SBC Program Manager Plans and Operations Division ACSIM	DSN 222- 9222 (703) 692- 9222	Linda.Smith@ hqda.army.mil

Problem Description:

Develop a SIPRnet web-based vulnerability and risk assessment (R&VA) tool called the Installation Vulnerability and Risk Assessment (IRVA). Designed to be integrated into the current Installation Status Report (IRR), it is intended for use by installation commanders to assess their exposure to threat attacks on their physical facilities and designed to have two levels of utility:

1. A high level reporting tool capable of presenting various summary assessment results of DoD installations with respect to R&VA that can form the basis for resource allocation intended to improve the system-wide R&VA status; and,

2. A local tool for use by installation commanders for reducing vulnerability to various attacks on "soft spots" present in an installation's normal operational systems.

Proposed Work:

- Perform a literature review and identify other DoD ongoing vulnerability assessment efforts. Establish client relationship with ACSIM, HQDA ISR/SBC Program and become familiar with the Installation Status Report and specifically the Services, Force Protection area.

- Develop a laptop-based R&VA demonstration model based on the Terrorism Threat and Vulnerability Risk Assessment Tool. Present Installation Vulnerability and Risk Assessment (IRVA) demonstration model to both sponsor and client and determine user requirements.

- Conduct site visits and interviews of stakeholders to include Defense Threat Reduction Agency (DTRA), ACSIM and installation commanders to define installation categories, installation vulnerability areas of assessment and to build question database. Observe a DTRA Vulnerabilities Assessment Team (VAT) and study previous VAT reports.
- Refine R&VA tool based on stakeholder input and determine ISR integration issues.
- Validate R&VA tool using previous VAT reports data.
- Test R&VA tool using 1-3 installations from different installation categories.
- Present R&VA tool for system-wide implementation.

Project Deliverables and Due Dates:

- Interim IPR: 22 January 2003.
- Final Briefing: 1 May 2003.
- Technical Report: 15 June 2003.

Senior Investigators: COL William Klimack, Ph. D., Associate Professor & Director – Operations Research Center, USMA-Department of Systems Engineering (845) 938-5529, Dr Patrick J. Driscoll, Ph. D., Professor of Operations Research, USMA-Department of Systems Engineering (845) 938-6587

Faculty Analyst(s): MAJ Patrick G. Magras, M. S., Assistant Professor & ORCEN Analyst, USMA-Department of Systems Engineering (845) 938-3573

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: TBD

Principal Analyst: 500 Hours

Lab Technician: 20 Hours

Total Cadet Time: 0 Hours

Lab Use Hours: N/A

Laboratory Technician Hours: N/A

Methodology for the Management of Power for the Soldier Tactical Mission System

Research Project No: DSE-R-0303

Client Organization: To be Determined (TBD). Potentially *Training and Doctrine Command (TRADOC) System Manager for the Soldier Tactical Mission System (TSM-Soldier)*

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL Theodore Johnson Project Manager PM-Soldier Systems	10125 Kingman Rd. Room 127 Ft. Belvoir, VA 22060-5852	DSN 654-3816 (703) 704-3816	Ted.Johnson@peosoldier.nvl.army.mil Fax (703) 704-1951
COL Walt Holton TSM-Soldier	Commander, USAIC ATTN: ATZB-S Fort Benning, GA 31905	DSN 835-1189 (706) 545-1189	Walter.Holton@benning.army.mil
MAJ Jim Smith APM-Power	PEO Soldier Ft. Belvoir, VA 22060	DSN 654-3769 (703) 704-3769	James.smith@peosoldier.nvl.army.mil
Mr. Pat Toffler	SY Technologies	DSN 688-8169 (845)938-8169	PatrickToffler@usma.edu
LTC Massie (USMA Power Project Coordinator)/Dr. Bailey	Dept of Civil and Mechanical Engineering USMA, West Point, NY 10996	DSN 688-4037/4105 (845) 938-4037/938-4105	Darrell.massie@usma.edu Margaret.bailey@usma.edu

Problem Description:

The Soldier Tactical Mission System current enstantiation is the Land Warrior (LW) system. Land Warrior may serve as a model for all STMSs, and the current Land Warrior version will likely be similar to the initial fielding. Regardless of evolution of STMSs, Land Warrior will be present in the inventory for some time. The PM Soldier Systems provides this description of Land Warrior (https://www.pmsoldiersystems.army.mil/public/FAQ/default.asp#q1):

Land Warrior (LW) is a first generation modular, integrated fighting system for the individual infantryman. The LW system includes everything the dismounted soldier wears and carries integrated into a close combat fighting system which enhances his situational awareness, lethality, and survivability. The LW System is composed of 5 integrated subsystems: Weapon Subsystem, Integrated Helmet Assembly Subsystem, Computer/Radio Subsystem (CRS), Software Subsystem, and Protective Clothing and Individual Equipment Subsystem. LW is intended for use by all five types of infantry; Ranger, Airborne, Air Assault, Light and Mechanized. LW will integrate the dismounted warfighter into the Army's digitized battlefield network.

There are 21 components to the Land Warrior system that require power. Unfortunately, current power source technology relies on batteries. Batteries are bulky and heavy so the LW soldier cannot carry a large number to power the components. Batteries only provide a power source for a limited duration, so they must be resupplied or recharged for long duration missions. Also, there is no alternate power source if the batteries are lost or damaged during a mission and resupply is not feasible.

Power management affords the greatest payoff in the soldier's power challenge. That is, the ability to efficiently manage energy utilization is achieved by incorporating adaptable hardware and "smart" software in a fully integrated soldier system architecture. The objective of power management is to use the minimum amount of power only when necessary in the most efficient manner. This objective will require closely coordinated control of all hardware and software subsystems. Future STMSs will likely demand increases in power draws and energy utilization without increasing the soldier system weight. Power management is a critical enabling technology that will enable the goals of a doubling of mission duration by 2004, and five to ten factor increase by 2008 without imposing additional weight on the soldier. These increases have been achieved in similar commercial systems, e.g., PDA's and laptop computers.

Clearly it is desirable that STMS power management receive analytical focus so that power management decisions are not required to be made expediently on the battlefield. Doctrine and information should be available to facilitate decision making by leaders of STMS-equipped units.

Problem Statement:

Management of the distribution of power for the Soldier Tactical Mission System

Objectives:

4. Determine tactical mission effectiveness for STMS components.
5. Develop guidance for reduction of STMS power consumption. At a minimum, this will be a binomial decision: on or off. If possible, where it is likely that multiple operational modes will be available for a subcomponent, the recommended subcomponent degradation will be refined.

Proposed Work:

The primary emphasis will be on the Land Warrior System v1.0. The proposed organization will be the squad or platoon.

6. Problem definition.
    - Conduct literature searches and background studies.
    - Discuss STMS power projects with other research agencies.
    - Develop engineering problem statement.
    - Develop value system.
    - Research and document information requirements with subject matter experts. Experts include but not limited to dismounted infantry, physiological, power supply/demand, and intelligence.
    - Identify critical components based on mission type.
7. Design and Analysis

- Develop the scenario vignettes that will be used in the analysis.
- Model and analyze alternatives using a simulation mode, specific model TBD.
- If possible, model and analyze alternatives using Agent Based Models, specific model TBD.
- Through interview, surveys, and/or previous research, ascertain SME opinion on the utility of the various components.

8. Decision Making
    - Establish at a minimum an order of merit of system (an ordinal ranking) components by mission type/situational conditions, which determine what components are the most effective.
    - Determine, if possible, the relative effectiveness of each component in relation to each other (a cardinal ranking), and utilizing that information develop an optimization model to determine what components should be on, standby, or off under what power conditions and what tactical mission/situation.

Requirements and Milestones:

Milestone	Date
Background Research	16 Sep – 28 Oct 02
Configuration & Methodology Definition	28 Oct – 12 Nov 02
Scenario Section/Definition	12 Nov – 2 Dec 02
Analytic Tool Selection/Analyst Self-education	2 Dec 02 – 18 Jan 03
Analysis of Alternatives	18 Jan – 18 Feb 03
Draft Report Completed	3 Mar 03
Final Briefing	TBD (anticipated for Apr 03)
Technical Report Completed	28 Arp 03

Project Deliverables:

A technical report documenting the findings of this research. Specifically it will:

- Provide a prioritized list of subcomponents for reduction of power consumption.
- Determine minimal power demand for each mission type. Specify which components must be on/off/standby.
- Specify what members of the unit need to have full power to the components.
- Provide input for power management TTPs for in the event of power degradation.

- Determine an estimate of effectiveness of power management recommendations based on lethality and survivability.
- Determine information requirements needed to enable the OFW software to manage distribution of power.

Senior Investigator: COL William K. Klimack, Ph. D, Associate Professor & Director, Operations Research Center, USMA–Department of System Engineering (845) 938-5529.

Faculty Analyst(s): MAJ David Sanders, M. S., Assistant Professor & ORCEN Analyst, USMA-Department of Systems Engineering (845) 938-5539, COL (Ret) Patrick Toffler, M. S., Director, Research & Study Partnership, ASA(AL&T)-USMA (845) 938-8169

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator:	0.0625 man-years
Principal Analyst:	0.375 man-years (30 hours/week for 26 weeks)
Lab Technician:	0.01 man-years
Total Cadet Time:	0.0 man-years
Total:	0.4475 man-years

Lab Use Hours: 1 hour/week (40 hours/year)

Laboratory Technician Hours: 0.5 hours/week (20 hours/year)

Small Aircraft Transportation System (SATS): Airspace Infrastructure Modeling and Simulation

Research Project No: DSE-R-0323

Client Organization: General Aviation Program Office, NASA/Langley Research Center

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
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Dr. Brent D. Bowen Director and Regents Distinguished Professor, Aviation Institute, Department of Public Administration, College of Public Affairs and Community Service and Director, Nebraska NASA Space Grant and EPSCoR Programs	422 Allwine Hall 6001 Dodge Street University of Nebraska at Omaha Omaha, NE 68182-0508	402-554-3424	unoai@unomaha.edu Fax: 402.554.3781

Background:

In terms of the national transportation strategy, SATS is a promising alternative to current commercial air travel. The landscape of air travel as we once knew it in this country has changed forever since the terrorist attacks on September 11, 2001. The SATS initiative promises to be a bona fide factor in the future as people increasingly seek more convenience and greater security in terms of their air travel options. The body of knowledge is lacking in research associated with midair conflict risk assessment and mitigation as it applies to SATS. SATS research is ongoing in several key areas. However, these are primarily concerned with determining socio-economic viability and developing aviation technology (onboard avionics, airport communication/ weather-reporting systems, and aircraft power plant design, among others). The airspace deconfliction challenge posed by SATS is formidable, and successful resolution is paramount to the realization of this concept. This research area needs to be exploited in the short term if SATS is to reach maturity by 2015, the FAA's stated goal

The applicability of this research to the Department of Defense is best seen in the parallels that can be drawn between SATS vehicles and future joint service aircraft. One of the cornerstones of SATS is reliance on advanced technologies for navigation and conflict resolution accomplished by onboard technology. This reduces the role of air traffic controllers in en route and terminal area handling. Future military aircraft, both in the Army and in our sister services, will be heavily dependent on digital communications and navigation, with a goal of making tactical aircraft as stealthy as possible. Airspace procedures developed to control commercial "smart" vehicles can be adapted to a tactical environment containing purely military aircraft, as well as joint civil-military aviation operations during peacetime in the National Airspace System (NAS).

Problem Description:

The proposed research will address several key SATS issues with respect to midair conflicts. First, it will seek to quantify midair conflicts in the congested terminal area airspace around specified U.S. population centers. Second, critical insights will be gained on the incidence of midair conflicts in the integrated NAS over the contiguous United States as SATS matures. Finally, the *SATS Cluster* will be introduced as the fundamental building block of state and regional SATS networks nationwide. This furthers research in support of the National Aeronautics & Space Administration (NASA) SATS initiative, as part of the National General Aviation Roadmap of the 21st Century. Research has been done that establishes the degree to which the incidence of en route midair conflicts can be expected to rise as air traffic volumes increase exponentially with SATS implementation.

Proposed Work:

This research will include expansion of a current modeling and simulation methodology developed by the researcher for his Master's thesis. The existing framework is centered on the creation of a test bed for SATS in the Commonwealth of Virginia and bordering states. This research will attempt to expand the modeled region. Modeling and simulation will be accomplished using the Total Airspace and Airport Modeler (TAAM) Plus, or comparable software. The original framework will be enhanced through increasingly accurate replication of aircraft flight characteristics and airport terminal airspace. Additionally, some assumptions from the original model will be relaxed to increase the complexity and realism of scenarios. A framework will be developed to capture delay data as well as data reflecting incidence of midair conflicts on a grander scale. Various optimization strategies will be explored as a means of maximizing safety and efficiency of SATS air travel. A methodology by which to model SATS clusters will also be explored. Possible mathematical applications include an examination of a graph theoretical approach to SATS networks.

Work that is anticipated in support of research projects will include examining previous methods for predicting midair conflicts between aircraft. These techniques will be applied within the SATS framework to determine their suitability for predicting collision risk between SATS vehicles. Additionally, a methodology will be established to model well defined, bounded regions of airspace. SATS collision risk probabilities will be quantified for such regions as a means of determining inherent SATS safety.

Deliverables:

Anticipated deliverables from this research will be in the form of a technical report. Results may be presented to the General Aviation Program Office of the NASA/Langley Research Center, as well as the National Center of Excellence for Aviation Operations Research and the Transportation Research Board.

Requirements and Milestones:

Research IPRs – Fall 2002 and Spring 2003 (dates TBD).

Proposed Required Date for deliverables: April 2003

Principal Analyst: MAJ Christopher M. Farrell, B. S. Instructor & ORCEN Analyst, USMA-Department of Mathematical Sciences (845) 938-5661

Senior Investigator: COL William K. Klimack, Ph. D., Associate Professor & Director, Operations Research Center, USMA-Department of Systems Engineering (845) 938-5529

Number of Cadets Involved: 1-4

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Total Cadet Time: 3 credit hours (MA491/SE491)

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

Soldier Tactical Mission System Component Optimal Distribution

Research Project No: DSE-R-0321

Client Organization: PEO Soldier

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
COL Theodore Johnson PM-Soldier Systems	10125 Kingman Rd. Room 127 Ft. Belvoir, VA 22060-5852	DSN 654-3816 (703) 704-3816 Fax (703) 704-1951	tjohnson@pmsoldier.belvoir.army.mil
COL Walt Holton TSM-Soldier	Commander, USAIC ATTN: ATZB-S Fort Benning, GA 31905	DSN 835-1189 (706) 545-1189	Walter.Holton@benning.army.mil
Mr. Pat Toffler	Dept of Systems Engineering USMA, West Point, NY 10996	DSN 688-8169 (845) 938-8169	PatrickToffler@usma.edu

Problem Description:

This research effort will examine the optimal distribution of Soldier Tactical Mission System (STMS) components at platoon level and below in tactical units. As commanders normally tailor the load of soldiers based on the factors of METT-T, it is likely that small unit leaders will, at some point, elect to have soldiers carry only a subset of the STMS. The number and mix of STMS subsystems becomes an optimality issue. This optimality question should be addressed through analysis and results incorporated into doctrine, as appropriate.

Currently, the standard STMS is the Land Warrior System. Land Warrior may serve as a model for all STMSs. The PM Soldier Systems provides this description of Land Warrior (https://www.pmsoldiersystems.army.mil/public/FAQ/default.asp#q1):

Land Warrior (LW) is a first generation modular, integrated fighting system for the individual infantryman. The LW system includes everything the dismounted soldier wears and carries integrated into a close combat fighting system which enhances his situational awareness, lethality, and survivability. The LW System is composed of 5 integrated subsystems: Weapon Subsystem, Integrated Helmet Assembly Subsystem, Computer/Radio Subsystem (CRS), Software Subsystem, and Protective Clothing and Individual Equipment Subsystem. LW is intended for use by all five types of infantry; Ranger, Airborne, Air Assault, Light and Mechanized. LW will integrate the dismounted warfighter into the Army's digitized battlefield network

Proposed Work:

A literature review will provide background information. Metrics for this study are planned to be soldier situational awareness, unit lethality, and unit combat effectiveness. It is anticipated that the study will use METL-based scenarios to apply individual task analysis and will examine cognitive and physical demands on soldiers as well as traditional tactical measure of effectiveness.

Project Deliverables and Due Date:

- Interim IPRs: TBD.
- Final Briefing: April 2003.
- Technical Report: April 2003.

Senior Investigator: COL William K. Klimack, Ph. D, Associate Professor & Director, Operations Research Center, USMA-Department of Systems Engineering (845) 938-5529.

Principal Analyst: CPT James Corrigan, M. S., Instructor, USMA-Department of Systems Engineering (845) 938-4888.

Number of Cadets/Number of Design Teams Involved: TBD

Supporting Laboratory Technician: TBD

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: TBD

Principal Analyst: TBD

Lab Technician: TBD

Total Cadet Time: TBD

Lab Use Hours: TBD

Laboratory Technician Hours: TBD

Airport Security for the 21st Century

Research Project No: DSE-R-0332

Client Organization: John Wayne Airport Commission

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Mr. Dave Helmreich John Wayne Airport	3160 Airway Avenue Costa Mesa, CA 92626	(949) 252-5200	
Mr. T. Robert Popov Popov Engineers, Inc.	19800 MacArthur Boulevard Suite 920 Irvine, CA 92612	(949) 752-0121 Fax: (949) 752-5813	popov@earthlink.net

Problem Description:

On November 19, 2001, President Bush signed a new security bill, the Aviation and Transportation Security Act (ATSA). This bill requires that each of the 429 airports regulated by the Federal Aviation Administration (FAA) must use explosive detection machines to screen 100% of checked baggage. The bill further states that they new system must be implemented by 31 December 2002.

Santa Ana Airport (SNA), one of the 429 airports regulated by the FAA, contacted Popov Engineers, Inc. (PEI), a consulting firm, to help with the implementation of the system. PEI specializes in mechanical, civil, and electrical engineering, and PEI decided that it would need some help to implement the system.

Mr. T. Robert Popov then took it upon himself to contact the United States Military Academy's Systems Engineering Department in order to look at the project from a system engineer's view, as he does not have these resources at PEI. The Department of Systems Engineering then agreed to help PEI with the airport security project.

Proposed Work:

The first step to solving this problem is to conduct extensive research and become the experts in the Corps about airport security. This research will consist of reading written articles concerning current and proposed future security, talking to the stakeholders in the problem, and finding and knowing the regulations needed for the airports to emplace the new security systems.

Once we research the problem, we must identify the best methodology for Santa Ana Airport to screen 100% of the baggage entering the airport. This analysis will include, but is not limited to, the flow of travelers at SNA during various days of the week, including holiday travel, how many passengers travel through the security system, to include workers of the airlines, and where and how many explosive detection devices the airport will structurally support.

When we have a good idea of what is needed, we will then need to model the problem using computer simulation. This simulation will be all-inclusive, and will need to work for any of the 429 FAA regulated airports in the United States.

Requirements and Milestones:

DATE	TOPIC	MEDIA
OCT 02	In Progress Review (Presentation)	Video Teleconference
NOV 02	IPR	In Person with Mr. Popov
DEC 02	IPR, Interim Report	Video Teleconference
FEB 03	IPR	Video Teleconference
APR 03	IPR, Interim Report	Video Teleconference
MAY 03	Final Presentation, Final Report	In Person with Mr. Popov

Project Deliverables and Due Date: Technical report giving findings and recommendation for tasks as above, May 2003

Senior Investigator: LTC Michael J. Kwinn, Jr., Ph. D. **.,** Assistant Professor, USMA-Department of Systems Engineering (845) 938-5941

Faculty Analysts: CDTs Donovan, Mahoney, Pelletier, Schmidt, and Smith

Number of Cadets/Number of Design Teams Involved: 5 Cadet/1 Capstone Team

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 200

Principal Analyst:

Lab Technician: None

Total Cadet Time: 2250 hours (5 cadets (4 in 2nd semester) x 250/semester)

Lab Use Hours: 100 hrs

Laboratory Technician Hours: 10 hours (consulting on ProModel, if necessary)

Analysis and Comparison of VoTech programs, current Military Occupational Specialties (MOS) and US Army Advanced Individual Training (AIT) requirements associated with these MOSs – Part 1.

Research Project No: DSE-R-0334

Client Organization: US Army Recruiting Command (USAREC)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
Al Liang	U.S. Army Recruiting Command, ATTN: RCPAE, 1307 Third Avenue, Ft Knox KY 40121-2726	(502) 626-1895 or (DSN) 536-1895	Alban.Liang@usarec.army.mil
LTC Robert Plummer	U.S. Army Recruiting Command, ATTN: RCPAE, 1307 Third Avenue, Ft Knox KY 40121-2726	(502) 626-0325; DSN 536-0325	Robert.Plummer@usarec.army.mil

Problem Description:

In August of 2001, then Commanding General USAREC, MG Cavin directed this command to develop and implement a college market expansion strategy. The FY02 command goal was to recruit 15.5% of all contracts from this college market. The command exceeded this goal and is expected to close the FY at approx 22.5%. The FY03 command goal is 25%. Goals for this market beyond FY03 have not been developed, but it is anticipated this command will continue to expand this market.

This recent command-wide shift in market orientation will result in recruiting more applicants with higher educational attainment than in the past. Educational attainment from this market ranges from applicants who have completed a few semester hours at a post-secondary institution to those who completed a Master's or other post graduate degrees.

The US Army and Army Reserve Civilian Acquired Skills Program (ACASP) is addressed in Army Regulation 601-210 Regular Army and Army Reserve Enlistment Program, dated Feb 95. This program currently allows applicants who completed appropriate civilian training to enlist in the Army in selected Military Occupational Specialties (MOS) at a higher grade and in some cases waive US Army Advanced Individual Training (AIT) attendance. This program offers applicants significant benefits for enlistment and the US Army benefits by reducing Training Base requirements and increasing utilization of soldiers during their first term of enlistment.

Many US Army Military Occupational Specialties (MOS) have been revised, consolidated and restructured since 1995. These changes include revising the training conducted during Initial Entry Training (IET). A comprehensive review of MOSs and training conducted during IET is necessary to update AR 601-210 and for the US Army to maximize the higher entry-level civilian education our recruits from this market will have.

The objectives of the overall study are:

a) Identify current US Army MOSs that have VOTECH associated training conducted during IET.

b) Analyze historical USAREC ACASP contract and accession production to identify overall trends across all MOSs in the program, identify MOSs with high production and identify MOSs with potential for future growth or inclusion into the program.

Proposed Work:

This study (VoTech, MOS and AIT Analysis - Part 1) will be conducted in 3 phases:

Phase I. The Department of Systems Engineering will conduct a literature search of all relevant information pertaining to The US Army and Army Reserve Civilian Acquired Skills Program (ACASP) and similar programs conducted by other branches of military services. The purpose of this literature search is to identify US Army MOSs with VOTECH associated training conducted during IET and identify civilian courses, degree programs and credentials related to the training conducted. The Department will create a database documenting all MOSs, VOTECH associated training conducted during IET and civilian credentials related to the MOS training conducted.

Phase II. The Department will conduct data analysis to review and analyze historical USAREC ACASP contract and accession production to identify overall trends across all MOSs in the program, identify MOSs with high production and identify MOSs with potential for future growth or inclusion into the program. The analysis will examine ACASP applicant demographics to include, but not limited to, primary Military Occupational Specialty (MOS), race, ethnicity, gender, test scores, civilian education level, and family status to create profiles of an ACASP applicant.

Phase III. The Department will develop a technical report and provide an oral presentation of the final report to the USAREC leadership at Fort Knox, Kentucky.

Requirements and Milestones:

Initial trip to USAREC for consultation – Nov 2002

Monthly IPRs to USAREC

Phase 1 Report – December 2002

Phase 2 Report – March 2003

Final technical report – June 2003

Project Deliverables and Due Date: See report schedule above

Senior Investigator: LTC Michael J. Kwinn, Jr., Ph. D. **.,** Assistant Professor, USMA-Department of Systems Engineering (845) 938-5941

Faculty Analysts: TBD

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 200 hours

Principal Analyst: 200 hours

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: None

Laboratory Technician Hours: None

Objective Force Manning and Personnel Development

Research Project No: DSE-R-0333

Client Organization: Program Manager – Objective Force

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
Dr. Jim Walbert	Chief Scientist PM – Objective Force DARPA/TTO 3701 North Fairfax Drive Arlington, VA 22203-1714	571-218-4406	jwalbert@darpa.mil

Problem Description:

The Future Combat System Lead System Integrator has been announced and the Organization and Operations for the Unit of Action has been written and distributed (limitedly). There remains, however a great deal of analysis for the future of the program beyond the initial development and employment.

As the FCS block improvements evelove, so too must the TTPs and doctrine. As robotics matures, less human attention will be required to guide and direct them. This could lead to a significant decrease in the exposure of soldiers to direct fire and, possibly, imminent dangers. These changes will effect the manning requirements of the force as well as the development of soldiers and leaders.

As has been shown in the past with, just because we can operationally eliminate levels of command, we must be careful as the interactions between leaders and soldiers can become dysfunctional.

Proposed Work:

This research seeks to project the structure of the future (2016 and beyond) Army as we improve our technology and determine how best to grow leaders to fit into the new proposed structure. We will conduct this research by comparing where we have been, where we are, where we will be (2008+) and where we are going (2016 and beyond). We will do this in four phases:

Phase 1. <u>Where we have been.</u> We will look at historical examples of structures of other armies, and some examples of past innovations in the US Army, worked. This will provide a vision of what works and does not work and why in structures.

Phase 2. <u>Where we are and where we will be</u>. We look at what TRADOC proposes for the Unit of Action and determine what, if anything needs to change in the force structure and development of soldiers and leaders. We will also include in the analysis measures being considered by the G1 task force on unit stabilization.

Phase 3. <u>Where we are going</u>. We will work with the Objective Force technologists to project potential changes in technology and communications and determine who these developments will change our functional requirements. We then will determine the appropriate manning and personnel development requirements to cover these functions. We will also address the training and doctrine requirements.

Phase 4. Doctrine and Development. We will analyze how doctrine and personnel development must change to cover the functions required for the future force. This analysis will account for the changes in technology in both military equipment and training management.

Requirements and Milestones:

IPRs for each phase

Phase 1: Nov 2002

Phase 2: Jan 2003

Phase 3: Mar 2003

Phase 4: May 2003

Final Technical Report: June 2003

Project Deliverables and Due Date: See report schedule above

Senior Investigator: LTC Michael J. Kwinn, Jr., Ph. D. ., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5941

Faculty Analysts: TBD

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 200 hours

Principal Analyst: 200 hours

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: None

Laboratory Technician Hours: None

Programmic Analysis of Recruiting Inputs

Research Project No: DSE-R-0331

Client Organization: US Army Recruiting Command (USAREC)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
LTC Robert Plummer	U.S. Army Recruiting Command, ATTN: RCPAE, 1307 Third Avenue, Ft Knox KY 40121-2726	(502) 626-0325; DSN 536-0325	Robert.Plummer@usarec.army.mil

Problem Description:

USAREC initiates numerous programs to facilitate their recruiting efforts. To date, analysis of these programs has not fully considered the impact of the efficiency of the management of the recruiting operations. This has resulted in a skewed view of the programs' effectiveness. In this research, we will separate the programmic effects from the managerial effects thereby providing clearer insight into the actual effectiveness of the given programs or initiatives.

Proposed Work:

The two primary researchers, LTC Kwinn and MAJ McCarthy will conduct an analysis of the efficiency and effectiveness of various U.S. Army recruiting inputs by combining Data Envelopment Analysis (DEA) and regression techniques. We will identify the program inputs that USAREC would like to analyze and gather the data necessary to conduct the analysis. We will then conduct a two-stage analysis. In the first stage, we will conduct an efficiency analysis of the operations of the individual recruiting Battalions. In the second stage, we will assign a dummy variable value of 1 to the efficient battalions and zero to the inefficient battalions. We will then conduct an OLS regression on the inputs and the dummy variables. This will allow us to identify the effects of the programs under efficient operation and inefficient operations.

Requirements and Milestones:

Identify specific programs to analyze	Nov 02
Obtain Software (DEA and regression)	Dec 02
Obtain Data Set	Jan 03
Build Database and Investigate Data	Feb-Mar 03
Build Models	Mar-Apr 03
Analyze Results/Validate	Apr-May 03
Submit Final Report	Jun 03

Project Deliverables and Due Date: See report schedule above

Senior Investigator: LTC Michael J. Kwinn, Jr., Ph. D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5941

Faculty Analysts: MAJ Daniel J. McCarthy, M. S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-4857

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 150 hours

Principal Analyst: 150 hours

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: None

Laboratory Technician Hours: None

Unit Manning Study

Research Project No: DSE-R-0328

Client Organization: Army G1

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
LTG John M. Le Moyne Deputy Chief of Staff, G1 United States Army	300 Army Pentagon Washington, DC 20310-0300	(703)-614-1862 DSN 224-1862	
MG Lawrence R. Adair Deputy G-1	300 Army Pentagon Washington, DC 20310-0300	(703)-692-1585	
LTC Karl Reed MG Adair's XO	300 Army Pentagon Washington, DC 20310-0300	(703)-692-1585	Karl.Reed@hqda.army.mil

Problem Description:

Background: The U.S. Army mans units through an individual replacement system. The G-1, at the direction of the VCSA, has formed a Task Force to investigate the issue of "unit manning" to determine a more effective method of supplying personnel for combat units. The D/SE has been asked to assist the task force by helping to develop a methodology for the task for to follow.

Problem:

The Army's current replacement system is based on replacing individual soldiers across the Army, which works against and breaks down unit cohesion. Changing the replacement system may off an opportunity to increase readiness and morale.

"If we don't fundamentally change the personnel system of the Army … then the sum total of all the rest of this will not be nearly as effective as it could be … the ultimate objective being more cohesive units, a more stable situations for soldiers and their families, and therefore higher readiness levels, as opposed to a personnel system right now ... that detracts from that."

SA White, quoted by *Army Times*, 16 SEP 2002

Assumptions:

- Corps, Divisions, and all subordinate unit locations will remain the same for the foreseeable future.
- There will be no changes to Army End Strength or Force Structure in the foreseeable future.
- No foreseeable changes to the number of battalion level and brigade level commands.
- No changes to Legacy Force TOEs.
- Transformation timelines for the interim force and objective force will not change.

- Recommendations for changing the Army Education System for junior enlisted, NCO, and officers coming out of the ADS21 Task Force and the Training and Leader Development Panel will remain in effect.

Objectives:

Assist Task Force in developing a personnel system that increases unit readiness of units and improves officer and soldier development.

SE/USMA role in this Task Force is to advise on procedures to use in investigating this issue rather than perform the actual analysis.

Proposed Work:

Make recommendations and attend initial Task Force meetings to assist the Task Force in establishing a methodology to pursue as it investigates this issue.

Requirements and Milestones:

Milestone	Date
Initial intro to project	12 Sep 02
Assist w/ Charter and Project Definition	16-19 Sep 02
Assist w/ COA development and Analysis	20 Sep – 18 Oct 02

Project Deliverables and Due Date:

A memorandum report documenting the activities of participants and promulgating recommendations.

Senior Investigator: COL Michael McGinnis, Ph. D., Professor and Head, USMA-Department of Systems Engineering (845) 938-2700

Principal Analyst(s): MAJ David Sanders, M. S., Assistant Professor & ORCEN Analyst, USMA-Department of Systems Engineering (845) 938-5539, LTC Andrew Glen, Ph.D., Assistant Professor, USMA-Department of Mathematical Sciences (845) 938-5988, LTC Jack Picciuto, Ph. D., Instructor, USMA-Department of Mathematical Sciences (845) 938-5619

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator:	15 hours/week for 4 weeks
Principal Analyst:	30 hours/week for 4 weeks
Lab Technician:	0 man-years
Total Cadet Time:	0 man-years
Total:	30 hours/week for 4 weeks

Lab Use Hours: 0

Laboratory Technician Hours: 0

Logistics Decision Support System

Research Project No: DSE-R-0313

Client Organization: TBD

Problem Description:

The Logistics Decision Support System will facilitate better and more efficient logistics forecasting by maneuver units. The decision makers who will use the system are the maneuver battalion support platoon leaders and the battalion S-4s.

Proposed Work:

Develop a DSS that can imported to a Palm Pilot to assist in the logistics forecasting done by maneuver units, and in particular, Battalion support platoon leaders and Battalion S-4s.

Requirements and Milestones:

Task	Date
Project Kickoff	Aug 02
Problem Definition	Sep 02
Research	Oct 02
Prototype Development	Nov 02
Present Prototype at INFORMS	Nov 02
Prototype Evaluation	Feb 03
Recommendations	Apr 03
Technical Report	May 03

Deliverables: Prototype and technical report summarizing findings and recommendations.

Proposed Required Dates for deliverables: 30 May 03

Senior Investigator: Dr. Gregory S. Parnell, Ph. D., Professor, USMA-Department of Systems Engineering (845) 938-4374

Principal Analysts: MAJ Holly West, M.B.A., Instructor, USMA-Department of Systems Engineering (845) 938-2510, MAJ Elizabeth Schott, M.S., Instructor, USMA-Department of Mathematical Sciences (845) 938-4014, CPT Jim Jackson,

M. S., Instructor, Department of Electrical Engineering and Computer Science (845) 938-5555

ORCEN Analyst: N/A

Number of Cadets Involved: 0

Supporting Laboratory Technician: Software support.

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 1 hours per week, 36 weeks = 36 hours

Faculty Analyst: 2 hours per week, 36 weeks = 72 hours

Total Cadet Time: 0 hours

Lab Use Hours: 3 hours per week.

Laboratory Technician Hours: 1 hour per week, 25 weeks = 25 hours

Modeling of Soldier Tactical Mission System (STMS) Combat Effectiveness

Research Project No: DSE-R-0318

Client Organization: PEO Soldier

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
COL Ted Johnson	PM Soldier Systems Ft Belvoir, VA	703-704-3816	ted.johnson@PEOSoldier.army.mil
MAJ Brian Cummings	PM Soldier Systems Ft Belvoir, VA	703-704-3816	brian.cumings@PEOSoldier.army.mil

Problem Description:

The Army needs an analytic model that quantifies combat capability and survivability of an infantry squad as a function of the technology attributes of the Soldier Tactical Mission System Combat Effectiveness. **Proposed Work:**

Using complex adaptive systems theory and agent based modeling to analyze the relationships between soldier system functions in many scenarios. We will use the soldier system functions that we developed last year as a starting point. We will use the simulation information to develop an analytical model that quantifies combat capability and survivability of an infantry squad as a function of the technology attributes of the Soldier System.

Requirements and Milestones:

Task	Date
Project Kickoff	Aug 02
CAS software selection	Sep 02
Preliminary Prototype Development	Nov 02
Preliminary Findings	Dec 02
Prototype Development	Feb 03
Prototype Evaluation	Mar 03
Recommendations	Apr 03
Technical Report	May 03

Deliverables: Client presentation and a technical report summarizing findings and recommendations.

Proposed Required Dates for deliverables: 30 May 03

ORCEN Analyst: N/A

Senior Investigator: Dr. Gregory S. Parnell, Ph. D., Professor, USMA-Department of Systems Engineering (845) 938-4374

Faculty Analyst: MAJ Randy Klingaman, M. S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-4753

Number of Cadets Involved: 1 in Fall and 3 in Spring

Supporting Laboratory Technician: Software support.

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 3 hours per week, 36 weeks = 108 hours

Faculty Analyst: 4 hours per week, 36 weeks = 144 hours

Total Cadet Time: Aug 02 - May 03

1 cadets, 10 hours per week, 18 weeks

3 cadets, 10 hours per week, 36 weeks

TOTAL = 180 hours + 540 hours=720 hours

Lab Use Hours: 3 hours per week

Laboratory Technician Hours: 1 hour per week, 25 weeks = 25 hours

Quantifying Army Transformation

Research Project No: DSE-R-0311

Client Organization: HQDA, DCSOPS (DAMO-ZR)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
COL James Boatner	HQDA, DCSOPS (DAMO-ZR), The Pentagon	(703) 697-2278	James.Boatner@hqda.Army.Mil
Mr. Vernon Bettencourt	HQDA, DCSOPS Technical Advisor	(703) 697-0367	bettevm@hqda.army.mil

Problem Description:

The DCSOPS Resource Analysis and Integration Office is the DCSOPS' executive for prioritization of Army programs. They require an objective, credible, and traceable analytical process to assess the ability of the Army 04 POM programs to meet Army transformation objectives.

Proposed Work:

Develop methodology for an objective, credible, and traceable analytical process to quantitatively assess how well the Army 04 POM programs meet the Army's transformation objectives. Develop and test the prototype on a sample of Army programs. Summarize the results of the evaluation and make recommendations for an improved process.

Requirements and Milestones:

Task	Date
Project Kickoff	Aug 02
Problem Definition	Sep 02
Research	Oct 02
Prototype Development	Dec 02
Prototype Evaluation	Feb 03
Recommendations	Apr 03
Technical Report	May 03

Deliverables: Client presentation and a technical report summarizing findings and recommendations.

Proposed Required Dates for deliverables: 30 May 03

Senior Investigator: Dr. Gregory S. Parnell, Ph. D., Professor, USMA-Department of Systems Engineering (845) 983-4374

Principal Analyst: MAJ Brian Stokes, M. S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5536

ORCEN Analyst: N/A

Number of Cadets Involved: 3

Supporting Laboratory Technician: Software support.

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 5 hours per week, 36 weeks = 180 hours

Faculty Analyst: 2 hours per week, 36 weeks = 72 hours

Total Cadet Time:
Aug 02 - May 03, 3 cadets, 10 hours per week, 36 weeks = 1080 hours

Lab Use Hours: 3 hours per week.

Laboratory Technician Hours: 1 hour per week, 25 weeks = 25 hours

Security & Storage Design for Soldier Tactical Mission Systems (STMS) at Installation Level

Research Project No: DSE-R-0312

Client Organization: PEO Soldier

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER / EMAIL:
COL Ted Johnson	PM Soldier Systems Ft Belvior, VA	703-704-3816	ted.johnson@PEOSoldier.army.mil
Mr. Ellis Mosely	PM Soldier Systems Ft Belvior, VA	703-704-3816	ellis.mosely@PEOSoldier.army.mil

Problem Description:

Determine the best means of providing cost-effective, trustworthy systems that enable the security, availability, maintenance, and accountability of selected items of soldier tactical mission equipment in garrison, during strategic deployment, and when deployed for training or operations. The system(s) must have knowledge of the operational status of hardware, equipment, and software to ensure that appropriate maintenance action is taken upon turn-in or receipt of issued items.

Proposed Work:

This project will focus on the installation level. We will review previous cadet work and MAJ Trevor W. Shaw's NPS thesis, "A Systems Engineering Design Analysis Of A U.S. Army Secure Storage System." Based on this analysis, we will perform a systems analysis to identify and evaluate alternative security and storage designs for the installation.

Requirements and Milestones:

Task	Date
Project Kickoff	Aug 02
Problem Definition	Sep 02
Value System Design	Oct 02
Alternative Identification	Nov 02
Alternative Evaluation	Dec 02
Model refinement	Feb 03
Improved Alternatives	Mar 03
Updated Evaluation	Apr 03
Technical Report	May 03

Deliverables: Client presentation and a technical report summarizing findings and recommendations.

Proposed Required Dates for deliverables: 30 May 03

Senior Investigator: Dr. Gregory S. Parnell, Ph. D., Professor, USMA-Department of Systems Engineering (845) 938-4374

Principal Analysts: MAJ Holly West, M. S., USMA-Department of Systems Engineering (845) 938-2519, COL (R) Patrick Toffler, M. S., Director, Research & Studies Partnership, ASA(AL&T)-USMA (845) 938-8169

ORCEN Analyst: N/A

Number of Cadets Involved: 1

Supporting Laboratory Technician: Software support.

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 3 hours per week, 36 weeks = 108 hours

Faculty Analyst: 2 hours per week, 36 weeks = 72 hours

Total Cadet Time:
Aug 02 – Dec 02, 1 cadets, 10 hours per week, 18 weeks = 180 hours

Lab Use Hours: 1 hours per week.

Laboratory Technician Hours: 1 hour per week, 25 weeks = 25 hours

A Comparative Analysis of Methods for Assessing Cost and Schedule Risk for Major Defense Acquisition Programs

Research Project No: DSE-R-0327

Client Organization: Office of the Secretary of Defense, Program Analysis and Evaluation, Cost Analysis Improvement Group (CAIG), Operations Analysis and Procurement Planning Division, Room BE 829, The Pentagon, Washington, D.C. 20301 - 1800

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Dr. Richard Burke (SES-3)	Director, OAPPD OSD, PA&E BE 829, The Pentagon Washington D.C. 20301-1800	(703) 697-5056 DSN 227 - 5056	Richard.Burke@osd.pentagon.mil
Mr. Steven M. Miller (GS-15)	OSD PA&E OAPPD BE 829, The Pentagon Washington, D.C., 20301- 1800	(703) 692-8039	Steven.miller@osd.pentagon.mil
Mr. Brian Gladstone	OSD PA&E OAPPD BE 829, The Pentagon Washington, D.C., 20301- 1800	(703) 697 - 0319	Brian.Gladstone@osd.pentagon.mil

Problem Description:

Historically, cost and schedule estimates for many of the Department of Defenses Major Acquisition Programs have severely underestimated the cost and effort required for the programs. There are many reasons why this occurs but one may be that the initial program estimates are overly optimistic. This optimism may be a result of the estimating methodology utilized by the acquisition agencies. Many agencies estimate program costs using parametric cost estimating tools on the major elements in the Work Break Down Structure. Each of the elements in the WBS are viewed and estimated individually. When analyzing the risk associated with each of these elements most analysts represent costs and schedule risk with triangle distributions. However, history tells us that a skewed distribution (a Weibull distribution or Beta distribution) may be a better representation of reality. Even using skewed distributions, it has been hypothesized by the OSD CAIG (Mr. Steve Miller) that program estimates will still be severely underestimated when using the WBS modeling approach. He has hypothesized that doing risk analysis at the WBS level does not represent the reality associated with how costs and schedule are impacted during program execution. The biggest concern is that the impact of correlation is ignored in the WBS modeling technique. By ignoring the inherent relationships between the various cost elements and assuming that they are independent our estimates are always going to be overly optimistic.

Proposed Work:

OSD would like someone to attempt to quantify the level of optimism associated with performing cost estimates using the WBS modeling approach. In order to do this, we will investigate the use of a scheduled based modeling approach where each of the major tasks associated with the program are modeled and assigned an appropriate amount of risk. Using simulation, we will investigate the differences between a schedule based estimating approach and a WBS level modeling approach. A schedule based model and a WBS based model will be developed for a "typical" satellite acquisition program. The two models will be analyzed and distributions for program costs established. Each of the distributions will be analyzed and compared. Using design of experiments, the importance of precedence will be investigated and if possible quantified in terms of its impact on program costs estimates. The final product will be a summary of each of the modeling techniques, the pro's and con's of each, an analysis of the differences and their impact on the realism of program cost estimates.

Requirements and Milestones:

- Project Definition & Scope 15 Nov 2002
- System Definition 15 Dec 2002
- Schedule Based Model 15 Mar 2003
- WBS Based Model 15 May 2003
- Analysis of Models 1 Jul 2003
- Briefing and Report 1 Sep 2003

Project Deliverables and Due Dates:

- Interim IPRs: 15 Jan 2003, 15 June 2003
- Technical Report: 1 Sep 2003.

Senior Investigator: Lt Col Edward A. Pohl, Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206

Principal Analyst(s): Junior Faculty Member (TBD)

Number of Cadets/Number of Design Teams Involved: SE or EM Special Study Cadet

Supporting Laboratory Technician: **None**

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 80 Hours

Principal Analysts: 120 Hours

Lab Technician: 20 Hours

Total Cadet Time: 80 Hours

Lab Use Hours: Approximately 20 (CASE LAB 1 or 2)

Laboratory Technician Hours: 20

Embedded Training Decision Support

Research Project No: DSE-R-0304

Client Organization: PM Tank

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
MAJ John P. Conway	TACOM	586 574 8209	conwayj@tacom.army.mil

Problem Description:

It is desired to develop methods to evaluate the benefits of having a training simulator embedded in an Abrams M1A2 tank. The purpose is to have the costs and benefits compared. In particular, it is desired to estimate the increase in readiness as measured by go-nogo percentage for the basic tasks that can be trained in a tank using a simulator, due to the availability of the simulator as the tank crew goes through basic work day.

Proposed Work:

Investigate the following questions:

a) What is the value of being able to train in the field?

b) Does the added flexibility of training in the field outweigh any potential loss of realism?

c) What are the risks associated with embedded training and does it reduce or increase mission risk?

d) Does the creation of embedded training reduce the training infrastructure or decrease their utilization of training centers to the point that they are no longer cost effective?

e) Are there benefits to enlarging the scope of training in the embedded trainers? For example, is distributed simulation a worthy avenue to pursue?

Requirements and Milestones:

- Final Report, interim reports as needed
- Trip to Fort Knox by Dr. Foote (completed)
- Interim Report to MAJ Jeff Voight - Dec 2002, (completed)
- Final Report - May 2003

Project Deliverables and Due Dates:

- Phase I - Gather data on tasks and learning parameters
- Phase II - Form a cadet team for analysis
- Phase III - Develop model
- Phase IV - Develop alternatives
- Phase V - compute model and deliver report

Senior Investigator: Lt. Col. Edward Pohl, Ph. D., Assistant Professor, USMA–Department of Systems Engineering (845) 938-5206

Faculty Analyst(s): Dr. Bob Foote, Ph.D., Professor, USMA–Department of Systems Engineering (845) 938-4893, MAJ Suzanne DeLong, M. S., Assistant Professor, USMA–Department of Systems Engineering (845) 938-5537, MAJ Daid Smith, M.S., Instructor, USMA–Department of Mathematical Sciences (845) 938-4016.

Number of Cadets/Number of Design Teams Involved: Cadet design team (2 SE majors).

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 8 hrs / wk

Principal Analyst: 8 hrs /wk

Lab Technician:

Total Cadet Time: 9 hrs/wk

Lab Use Hours: None

Laboratory Technician Hours: None

Fleet Selective Maintenance and Aircraft Scheduling

Research Project No: DSE-R-0324

Client Organization: The Logistics Institute (TLI), University of Arkansas, Fayetteville, AR

Sponsoring Agency: Air Force Research Laboratory, Human Effectiveness Directorate, Logistics Readiness Branch, Wright Patterson AFB, Dayton Ohio

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
C. Richard Cassady, Ph.D.	The Logistics Institute Department of Industrial Engineering 4207 Bell Engineering Center Fayetteville, AR 72701	(479) 575 - 6735	cassady@engr.uark.edu

Problem Description:

All military organizations depend on the reliable performance of repairable systems for the successful completion of missions. The use of mathematical modeling for the purpose of modeling repairable systems and designing optimal maintenance policies for these systems has received an extensive amount of attention in the literature. Unfortunately, traditional studies in maintenance planning are limited in two key ways. First, they tend focus on a single system. This focus ignores the possibility that the system may be part of a fleet that shares responsibility for performing missions and resources for performing system maintenance. Second, they tend to ignore the mission profile of the system. This shortcoming prevents the modeler from considering important maintenance strategies including (1) performing maintenance during scheduled downtime, and (2) delaying maintenance to execute a critical mission. For the USAF fleet, these limitations are too severe to provide meaningful guidance relative to fleet maintenance planning. For a single aircraft, maintenance decisions should be made relative to its mission schedule. In addition, sortie scheduling decisions should be managed with considerations for aircraft maintenance. Given that the USAF fleet shares maintenance resources (spares, labor, etc.) and performs missions as a group, this integrated scheduling/maintenance planning problem can become quite complex. The objective of this project is to investigate the use of a mathematical modeling methodology for managing the dynamic, maintenance planning and sortie-scheduling problem.

Proposed Work:

Achieving the objective of this project requires the completion of several key activities. First, we will define a hypothetical aircraft fleet. This definition will include specification of an aircraft type, the number of aircraft, the mission profile and the constrained maintenance resources. Second, we will formulate a mathematical model which integrates the aircraft assignment (given a sortie schedule) and selective maintenance decision-making problems. Note that selective maintenance refers to the process of identifying the subset of actions to perform from a set of desirable maintenance actions. Third, we will develop a solution procedure for solving the integrated problem. We will define an enumerative procedure for smaller problems and investigate the use of search-based heuristics for larger problems. Fourth, we will study the behavior of the integrated problem using extensive numerical experiments. This study should provide insights into and heuristic rules of thumb for managing the integrated problem. Finally, we will study the dynamic, integrated problem. In other words, we will consider the problem of updating aircraft assignments and maintenance decisions when the sortie schedule changes and/or we experience significant aircraft component failures.

Requirements and Milestones:

The methodology used in this project will be applicable to any fleet of repairable systems that perform missions as a group and share maintenance resources. With the guidance of our USAF partners, we will apply our methodology to a hypothetical fleet that is representative of a specific type of aircraft.

Milestone 1 – Fleet Definition – Dec 31, 2002

> We will begin by developing the modeling structure necessary to study a hypothetical aircraft fleet. The aircraft type will be specified, and a corresponding reliability block diagram (RBD) will be constructed to capture the critical components comprising the aircraft. For each component, an appropriate reliability model will be defined, a model for the impact of maintenance on the component will be defined, and the resources required to perform maintenance will be specified. For the fleet, the required sortie schedule and the capacities on the maintenance resources will be quantified.

Milestone 2 – Static Problem Formulation – May 31, 2003

> We will formulate a mathematical model which captures the following aspects of the integrated aircraft assignment and maintenance problem for each aircraft: its current status, its next maintenance plan, its next sortie. This formulation process will begin with a review of the selective maintenance and integrated scheduling and maintenance planning literature. We expect to make extensive use of models previously studied by the PI.

Milestone 3 – Static Problem Solution and Analysis – Sep 30, 2003

> Once the static problem is formulated, we will develop a solution procedure for solving the static problem. For smaller problems, we will utilize an enumerative strategy. For larger problems, we will explore the use of search-based heuristics. In both cases, we will study the static problem via extensive numerical examples. Our goal is to gain insight into the behavior of the static problem so that we can define and test rules of thumb for managing the integrated aircraft assignment and maintenance problem.

Milestone 4 – Dynamic Problem Formulation – Dec 31, 2003

As with all decision problems, conditions governing the decisions evolve over time. So, we will next consider the dynamic, integrated problem. In other words, we will develop a strategy for updating the aircraft assignment and maintenance plan when conditions change. Condition changes include changes to an aircraft's status and/or changes to the sortie schedule. Our strategy will include the static problem incorporated within a discrete-event simulation environment which captures these stochastic changes.

Milestone 5 – Dynamic Problem Solution and Analysis – May 31, 2004

Once we have developed our static problem methodology, we will study it extensively using numerical examples. In addition, to gaining insight into the behavior of the dynamic problem, we hope to compare the performance of our integrated, dynamic methodology to the heuristic approaches used by fleet managers.

Milestone 6 – Documentation – Jun 30, 2004

Throughout the project, we will document our research and provide regular updates to our USAF partners. As part of this documentation effort, we will prepare a comprehensive final report at the end of the project.

Project Deliverables and Due Date:

- Interim IPRs: Jan 2003
Jul 2003
Nov 2003
Mar 2004
- Final Briefing: Jun 2004
- Technical Report: Jun 30th 2004.

Principal Investigators: University of Arkansas Graduate Student, USMA Junior Faculty Member - TBD

Senior Investigators: C. Richard Cassady, Ph.D. (University of Arkansas-Grad Student), Lt Col Edward A. Pohl, Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206

Faculty Analyst(s): TBD

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 10 hours per month

Principal Analyst: 20 hours per month

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: N/A

Laboratory Technician Hours: N/A

Multi-Mission Selective Maintenance Decisions

Research Project No: DSE-R-0326

Client Organization: The Logistics Institute (TLI), University of Arkansas, Fayetteville, AR

Sponsoring Agency: Air Force Research Laboratory, Human Effectiveness Directorate, Logistics Readiness Branch, Wright Patterson AFB, Dayton Ohio

Points of Contact:

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C.. Richard Cassady, Ph.D.	The Logistics Institute Department of Industrial Engineering 4207 Bell Engineering Center Fayetteville, AR 72701	(479) 575 - 6735	cassady@engr.uark.edu

Problem Description:

All military organizations depend on the reliable performance of repairable systems for the successful completion of missions. The use of mathematical modeling for the purpose of modeling repairable systems and designing optimal maintenance policies for these systems has received an extensive amount of attention in the literature. Unfortunately, the vast majority of this work ignores potential limitations on the resources required to perform maintenance actions. This shortcoming has motivated the development of models for selective maintenance, the process of identifying the subset of actions to perform from a set of desirable maintenance actions. Previously, we have developed a class of mathematical models that can be used to identify selective maintenance decisions for the following scenario – A system has just completed a mission and will begin its next mission soon. Maintenance cannot be performed during missions; therefore the decision-maker must decide which components to maintain prior to the next mission. The selective maintenance models considered to date treat decision-making relative to a single, future mission. If a system is required to perform a sequence of missions, then the selective maintenance decisions directly affect system reliability for the next mission and indirectly affect the system reliability for later missions. The primary objective of this project is to develop a modeling-based methodology for managing selective maintenance decisions when the planning horizon is more than one future mission.

Proposed Work:

Achieving the objective of this project requires the completion of several key activities. First, we will modify the existing selective maintenance models into a multi-mission problem formulation. To complete this activity, we will extend the problem parameters and decision variables to account for multiple missions and capture the stochastic relationship between the decision variables for mission t and the input parameters for mission $t + 1$. Second, we will define an appropriate objective function that captures system reliability across the entire sequence of missions. Given the stochastic nature of the problem, we will most likely use a weighting approach that gives heavier weight to the reliability of closer missions. Third, we will define an approach for solving the multi-mission problem. To do this, we will use the single-mission selective maintenance model in conjunction with a discrete-event simulation model that mimics the completion of missions. After each simulated mission, we will use the single-mission selective maintenance model to determine optimal decisions for the break prior to the next mission. For smaller problems, we will use enumerative approaches to determine the optimal selective maintenance decisions. For larger problems, we will use search-based heuristics to make these decisions. Finally, we will study the multi-mission problem using extensive numerical experimentation. This experimentation will be used to test our solution approaches, to gain insights into the multi-mission problem, and to identify "rules of thumb" for managing the multi-mission selective maintenance problem.

Requirements and Milestones:

The methodology used in this project will be applicable to any repairable system that performs a sequence of missions with system maintenance between missions. With the guidance of our USAF partners, we will apply our methodology to a set of hypothetical systems that are representative of commonly-used Air Force systems.

Milestone 1 – System Defintion – Dec 31, 2002

> We will begin by defining a set of hypothetical systems for study. These systems will be defined such that they capture the key elements of real USAF systems. For each system, we will define a reliability block diagram (RBD) that incorporates the critical components for the system.

Milestone 2 – Multi-Mission Selective Maintenance Modeling – Jun 30, 2003

> We will extend existing selective maintenance models by including expanding the planning horizon to multiple missions. This will require the modification of the models' parameters and decision variables. Furthermore, we will be required to capture the stochastic relationship between the parameters/decision variables for mission t and the parameters for mission $t + 1$. The objective function for the multi-mission models will be a weighted average of the mission reliability values, with heavier weight being applied to nearer missions.

Milestone 3 – Multi-Mission Solution Procedures – Dec 31, 2003

> We will develop a solution procedure to solve the multi-mission problem. We anticipate using a simulation-based approach to capture the stochastic elements of the problem, and we expect to use the single-mission problem as part of this procedure.

Milestone 4 – Numerical Analysis – May 31, 2004

> We will study the multi-mission problem via extensive numerical experimentation. Our goal for this experimentation is to compare the results for mission 1 to comparable results for the single-mission problem. This comparison will indicate the necessity of using the multi-mission model as opposed to using

the single-mission problem is a sequential fashion. Regardless of the outcome, we hope to gain insights into the multi-mission problem that can be used in developing rules of thumb for managing the selective maintenance problem.

Milestone 5 – Documentation – Jun 30, 2004

Throughout the project, we will document our research and provide regular updates to our USAF partners. As part of this documentation effort, we will prepare a comprehensive final report at the end of the project.

Project Deliverables and Due Dates:

- Interim IPRs: Jan 2003
  Jul 2003
  Nov 2003
  Mar 2004
- Final Briefing: Jun 2004
- Technical Report: 30 Jun 2004.

Principal Investigators: University of Arkansas Graduate Student, USMA Junior Faculty Member (TBD)

Senior Investigators: C. Richard Cassady, Ph.D. (University of Arkansas-Grad Student), Lt Col Edward A. Pohl, Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206

Faculty Analyst(s): Junior Faculty member - TBD

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 10 hours per month

Principal Analyst: 20 hours per month

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: N/A

Laboratory Technician Hours: N/A

Quantifying the Impacts of Aircraft Cannibalization

Research Project No: DSE-R-0325

Client Organization: The Logistics Institute (TLI), University of Arkansas, Fayetteville, AR

Sponsoring Agency: Air Force Research Laboratory, Human Effectiveness Directorate, Logistics Readiness Branch, Wright Patterson AFB, Dayton Ohio

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
C. Richard Cassady, Ph.D.	The Logistics Institute Department of Industrial Engineering 4207 Bell Engineering Center Fayetteville, AR 72701	(479) 575 - 6735	cassady@engr.uark.edu

Problem Description:

Fleet aircraft maintenance involves a variety of activities that are intended to maximize the readiness of the fleet without violating budgetary constraints. One such activity is cannibalization. While cannibalization provides a short-term fix that makes one aircraft available, its long-term impacts can be significant. Because of the military's focus on fleet readiness and the expense of maintaining large component inventories, all military services rely extensively on cannibalization and consider it to be a normal part of fleet maintenance. A recent five-year study identified approximately 850,000 documented US Air Force and Navy cannibalizations, which consumed 5.3 million maintenance hours (equivalent to 500 full-time aircraft maintenance personnel). Other downsides of cannibalization include reduced morale of maintenance personnel, extended downtime periods for the cannibalized "hangar queens", and induced mechanical problems ("Cannibalization", *Air Force Magazine*, March 2002). The objectives of this project are to develop a mathematical modeling methodology for assessing the impact of cannibalization on fleet performance, identify policies for making cost-effective, dynamic cannibalization decisions, and study the impact of these policies on management of the spare parts supply chain.

Proposed Work:

In order to fulfill the objectives of this project, a sequence of modeling and analysis activities must be completed: (1) Delineation of the aircraft fleet – An appropriate aircraft system structure and other fleet characteristics will be defined; (2) Description of aircraft reliability – Traditional reliability and aging models will be defined for each aircraft component at an appropriate work unit code level (2 or 3 digit); (3) Description of aircraft maintainability – Repair times for components maintained on-site, lead times for components maintained at a depot, and additional maintenance hours resulting from cannibalization will be defined; (4) Specification of current cannibalization practices; (5) Development of a simulation model which captures fleet operation and maintenance (including cannibalization) – Fleet performance measures captured by the model will includes measures of readiness, labor consumption and cost; (6) Development of revised cannibalization policies – Through experimentation with the simulation model, modifications to existing cannibalization practices will be explored. The impact of the existing and revised cannibalization policies on the management of the spare parts supply chain will be explored.

Requirements and Milestones:

The methodology used in this project will be applicable to any aircraft fleet. However, with the guidance of our USAF partners, we will apply our methodology to a hypothetical fleet. This fleet will be modeled such that it represents relevant issues related to aircraft cannibalization.

Milestone 1 – Fleet Delineation – Dec 31, 2002

> We will define the parameters governing the behavior of the aircraft fleet under consideration. First, we will define the aircraft under consideration and create a reliability block diagram (RBD) that describes the structure of the aircraft. Second, we will identify the facilities served by these aircraft. The potential origins and destinations for flights will be enumerated, and the maintenance capability of each facility will be defined. Third, we will model the mission profile for the aircraft fleet. This model will include a schedule of flights and a policy for assigning aircraft to flights.

Milestone 2 – RAM Modeling – Mar 15, 2003

> For each component in the aircraft RBD, we will model the component's reliability and maintainability characteristics. Traditional models, e.g. exponential and Weibull life distributions, will be utilized to capture component reliability. For component maintainability, traditional models such as renewal and minimal repair will be considered. Repair times for on-site maintenance, lead times for depot maintenance, and cannibalization times will be specified. Inventory policies for spares will be delineated.

Milestone 3 – Cannibalization Policy Definition – Mar 15, 2003

> We will identify typical decision-making processes used by USAF maintenance personnel relative to cannibalization. Furthermore, we will review the literature on cannibalization policies.

Milestone 4 – Simulation Modeling – Aug 15, 2003

> We will construct a simulation model that mimics the operation and maintenance (including cannibalization) of the aircraft fleet and estimates several metrics including aircraft readiness, maintenance labor consumption, and inventory cost. We will study fleet performance via extensive experimentation with the simulation model.

Milestone 5 – Improving Fleet Performance – May 15, 2004

We will use the results of our literature review and our simulation experiments to explore two avenues for improving fleet performance. First, we will explore revised polices for aircraft cannibalization. Second, we will explore revised policies for managing the spare parts supply chain. This portion of the study will require modification to the simulation model and additional experimentation. Our intention is to identify the key fleet parameters that influence the need for and impact of cannibalization so that we can make general recommendations regarding cannibalization and spares supply chain management.

Milestone 6 – Documentation – Jun 30, 2004

Throughout the project, we will document our research and provide regular updates to our USAF partners. As part of this documentation effort, we will prepare a comprehensive final report at the end of the project.

Project Deliverables and Due Dates:

- Interim IPRs: Jan 2003
  Jul 2003
  Nov 2003
  Mar 2004
- Final Briefing: Jun 2004
- Technical Report: 30 Jun 2004

Principal Investigators: University of Arkansas Graduate Student, USMA Junior Faculty Member - TBD

Senior Investigators: C. Richard Cassady, Ph.D. (University of Arkansas-Grad Student), Lt Col Edward A. Pohl, Ph.D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-5206

Number of Cadets/Number of Design Teams Involved: None

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 10 hours per month

Principal Analyst: 20 hours per month

Lab Technician: None

Total Cadet Time: None

Lab Use Hours: N/A

Laboratory Technician Hours: N/A

Deployment Scheduling Analysis Tool (DSAT)

Research Project No: DSE-R-0315

Client Organization: Military Traffic Management Command Transportation Engineering Agency (MTMCTEA)

Points of Contact:

NAME:	ADDRESS:	PHONE:	OTHER:
Mr. Mike Williams	Chief, Deployability Division MTMCTEA\ 720 Thimble Shoals BLVD Newport News, VA 23606-2574	757-599-1639	WilliamM@tea-emhl.army.mil

Problem Description:

The Deployment Scheduling Analysis Tool (DSAT) is a simulation-based tool for studying military deployment scenarios that run on a personal computer. The client utilizes the DSAT in Objective Force Power Projection studies for the CAA. As transformation moves forward, the DSAT is required as a quick-look tool in deployment planning and must be upgraded to reflect changes.

Proposed Work:

Provide continued maintenance and upgrades to the DSAT as required. Provide external analysis using the DSAT to augment MTMCTEA's power projection studies and deployment analysis.

Requirements and Milestones: Maintain and upgrade the DSAT as required.

Senior Investigator: LTC Timothy Trainor, Ph. D., Assistant Professor, USMA-Department of Systems Engineering (845) 938-3688, LTC Barbara Melendez, Ph. D., Assistant Professor, USMA-Department of Mathematical Sciences (845) 938-7436

Principal Analyst(s): MAJ Russell J. Schott, M.S., Instructor, USMA-Department of Systems Engineering (845) 938-4752, MAJ Brian Layton, M. S., Assistant Professor, USMA-Department of Systems Engineering (845) 938-3392, MAJ Elizabeth Schott, M. S., Instructor, Department of Social Sciences (845) 938-4014

Number of Cadets/Number of Design Teams Involved: None - Possible Capstone and AIAD to be coordinated.

Supporting Laboratory Technician: None

Resources Required for Project:

Research Hours Required (by position):

Senior Investigator: 100 hours

Principal Analysts: 150 hours

Lab Technician: 0 hours

Total Cadet Time: 0 hours

Lab Use Hours: 2 per week, CASE 2

Laboratory Technician Hours: 20

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Early Entry Lethality and Survivability Cdr, USATRADOC	ATTN: ATCD-L Ft. Monroe, VA 23651-5000	1
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	TOTAL	66